A MANUFACTURING VENTURE

PLANNING MODEL

A THESIS

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PLANNING MODEL

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SUMMARY

This thesis concerns the design, development and application of a computer implemented planning model for use as a tool in the new venture planning process. Discussion of this model is preceded by a review of 16 planning models contained in the literature. A classification scheme is presented which allows for comparison of model characteristics.

The model described here is intended to be useful in real-world planning situations and for teaching and research purposes. The Manufacturing Venture Planning Model (MVPM) possesses the following attributes:

1) Explicit treatment of productive processes and associated flows of nonfinancial resources, as well as provision of financial information.
2) A general design so as to be applicable in a wide variety of business venture planning situations.
3) An orientation toward the manufacturing enterprise.
4) A deterministic, case study, simulation modeling approach.
5) A formulation which allows for extensive on-line interaction between the model and a typical business planner with little or no computing experience.

MVPM accepts as input, data concerning the marketing, technical/manufacturing, and administrative/financial aspects of business venture planning. Reports are created which give information on pro forma operations over a five year planning period. The user may request

Operations Reports which describe usage of nonfinancial resources on a monthly or annual basis and various financial reports including cash flow (monthly and annual), income statement (quarterly and annual), present worth of venture net cash flow (end of planning period), and ratio analyses (annual). A plot of venture net cash flow can also be produced.

The application of the model to new venture planning data is demonstrated. The venture configuration examined is that of a small manufacturer of desk-top staplers.

The computer model is written in the FORTRAN language, and contains minimal use of language features which would inhibit transportability. Partial source code for the model appears in an appendix.

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CHAPTER I

INTRODUCTION

1.1 Problem Environment

The subject of this work is the development of a computer-implemented planning model for new business ventures. The model is general in nature, but decidedly oriented towards the manufacturing enterprise.

The casting of the model as a "new venture planning model", is significant. Experience has shown that, for a going concern, an effective model must be situation specific and the outgrowth of cooperative effort on the part of insiders [27,30,37]. Hayes and Nolan wrote that "Planning models cannot be built by specialists who are not familiar with the company and its planning process. Knowledge of why and how planning is accomplished is necessary [30]." Thus the difficulty with attempts to apply a general model to an existing firm stems from organizational and operating idiosyncracies which have evolved over the course of its existence.

This objection to a generalized approach disappears when the circumstances surrounding the analysis of a new venture proposal are considered. Here the planning and budgeting process has not been established. Even those most intimately involved with the venture must work with "educated" guesses about the nature of day-to-day operations and flows of information. Careful planning may reveal _a priori_ the need for certain operating practices, but the inherent uncertainty of future events dictates that some changes can and will occur. The net result is that with all of the "noise" present in the data available for use in the venture planning problem, the additional imprecision introduced by the lack of company-specific design is much less of a deterrent. The impetus for creation of a general model of this type is the belief that the benefits gained from use of the power of the computer outweigh the costs associated with the difficulties described above. The manner in which the use of computer models positively affects the planning process is discussed in Chapter III.

A manufacturing orientation was chosen for two reasons. First, manufacturing ventures typically require higher levels of initial capitalization compared with ventures in service industry areas. Thus the use of enlightened feasibility analysis is mandated by the magnitude of investment required. Second, the characterization of functional areas in a manner appropriate for a manufacturing enterprise lends itself to characterization of nonmanufacturing organizations. It is not difficult to conceptualize the product activities of a service industry as productive "processes."

Finally, it should be reiterated that the focus of the model is the new venture planning and feasibility analysis process. Thus emphasis is placed, not on sophistication of methodology, but on a pragmatic approach to providing information needed by the entrepreneur or other analyst of a new venture proposal.

1.2 Statement of Objective

The objective of this work was to develop a computer-implemented model for use:

1) In new venture planning and feasibility analysis.
2) As a tool for educational activity and a stimulus for further research

A review of the literature was carried out to determine the most desirable attributes of such a model. This review, which is contained in Chapter II, led to the specification of specific desirable attributes which are set forth in Chapters II and III, and summarized below:

1) Explicit treatment of productive processes and associated flows of nonfinancial resources, as well as provision of resultant financial information.
2) A general design so as to be applicable in a wide variety of business venture planning situations.
3) An orientation toward the manufacturing enterprise.
4) A formulation which allows for extensive on-line interaction between the model and a typical business planner with little or no computing experience.

The balance of the thesis concerns the evolution of the model and demonstration of its use.

CHAPTER II

A REVIEW OF PLANNING MODELS

2.1 Survey of Modeling Activity

The literature of management science and operations research contains numerous descriptions of modeling efforts. Most of these models are of the optimization type, a fact noted by Grinyer and Batt [26] in their survey of modeling literature.

One is more apt to find expositions of case study simulation models in publications oriented toward business managers. The most comprehensive collection of papers regarding these models is "Corporate Simulation Models" edited by A.N. Schrieber [53]. The bulk of the modeling described there and in business journals is concerned with aspects of financial planning in specific large corporations. The depth and nature of model description varies greatly. This is not surprising in view of the proprietary nature of many of the models presented.

Work by authors who have looked (respectively) at modeling literature and practice shows some interesting differences between academic research and activities of modeling practitioners. The survey by Grinyer and Batt [26] of 34 papers in which models were described shows that 50 percent of these models were deterministic simulation models, 26 percent were case study type simulation models allowing for stochastic inputs, 15 percent mathematical programming models, and 7 percent deterministic econometric models.

In a survey of 323 companies (members of the Planning Executives Institute) Gershefski [22] found that 95 percent of models in use were of the case study simulation type, and 5 percent were mathematical programming models. This predominance in practice of "alternative testing" simulation models ahs been corroborated in a subsequent study of planning practice by Dickson, Mauriel and Anderson (DMA) [14]. They did, however, find a trend toward simulation models which incorporate optimization in some model segments.

Gershefski found that 65 percent of the companies building models used a top-down "total corporation" approach. The remaining models were "bottom-up" in the sense that they considered in detail specific functional areas of the company. The same predominance of top-down modeling was also found by DMA. Grinyer and Batt in their examination of planning literature found bottom-up modeling to be more prevalent. Autonomy of lower level management, and modular modeling of increasingly complex firms are reasons given by DMA for a prediction that more bottom-up modeling will be done in the future.

The majority of the models examined by Gershefski, and all of those discussed by DMA were financial statement of generators. The latter study noted a trend among such models toward built-in financial analysis. This usually involved computation of important financial ratios.

Since managers typically think in terms of differences or changes in situation (Mathes [42]), it would be useful for such information to be included in model reports. However, DMA found that the effective use of exception reporting was rare. Additionally, none of the models they analyzed had the capability of making online comparisons between model trials.

There exists a paucity of model descriptions in the literature which deal specifically with small business or new business ventures. While there is an abundance of information regarding manufacturing models, most of this concerns specific manufacturing operations, e.g., job shop scheduling or real-time process control. The papers discussing modeling of the whole firm with treatment of its constituent productive activities are few. DMA have predicted that additional emphasis will be placed on modeling of nonfinancial resources. They state that "...estimation of personnel requirements (by skill), facility needs (by type) and technological needs (by type) can reasonably be expected to be included more often in corporate models in the near future."

The following is a sample of extant corporate modeling as described in the literature. To facilitate an organized presentation of this material, the models are classified into five broad categories: optimizing, case study/simulation, simulation languages (all three previous classifications pertain to financially oriented modeling), small business models, and models of the firm which contain explicit consideration of manufacturing and nonfinancial resources. This categorization is admittedly artifical: usually a given model could be subsumed in more than one category. Consequently, the last section of this chapter illustrates the characterizations applicable to each model cited.

The content of the model descriptions varies from category to category to allow emphasis on important characteristics of each model class. Discussion of mathematical programming models will generally center around aspects of the methodologies employed. Since the approach to finding a "good" solution via use of a simulation model is universal, discussion of this class of model will be concerned with input and output format, as well as salient features of model construction.

Those models chosen for examination in each category are given below, with either the author or model name being used as applicable.

1) Financial Planning Models: Optimizing

   Carlton, Dick and Downes (CDD) [5]

   Dickens [15]

   Hamilton and Moses [28]

2) Financial Planning Models: Simulation

   Burrill [4]

   Gershefski [23]

   Stone, Downes, and Magee (SDM) [61]

3) Planning Languages

   PROPHIT II [49]

   PSG II [48]

   FAPS [18]

4) Small Business Models

PPCS [32]

SMALBIS [8]

DesJardins and Lee [13]

5) Manufacturing Company Models

Baker and Damon [1]

Chambers, Mullick and Smith (CMS) [6]

Harrison and Baker [29]

Smith [57]

Most of the models cited in this chapter deal with specific large corporations. This material is provided to give information about current modeling activity. It does not purport to be a comprehensive survey of all corporate modeling. For a more complete examination the reader is referred to the surveys cited above. The intent here is to provide a frame of reference appropriate for evaluation of the model which is the subject of this thesis. In accordance with this objective, a more rigorous treatment of models dealing with small, new, and manufacturing enterprises is made.

2.2 Financial Planning Models: Optimizing

The model of Carlton, Dick and Downes (CDD) [5] has as its overall methodology, the use of optimization in a case study fashion. Their model is interactive and user oriented to provide for fast turnaround and ease of use. This speed of operation is essential, since the model is designed to provide an optimal solution for a given set of input data, and then to provide additional optimal solutions for subsequent revisions of input values. They thus seek to combine the resolution of complexity possible through the use of mathematical programming with the evaluation of alternative parameter assumptions performable with simulation models. This process of user evaluation of model output and revision of model inputs is illustrated in Figure 2.1.

The model is specifically intended as an aid to top management in financial planning. The authors felt that excessive amounts of accounting detail would detract from management concentration on information needed for the financial decisions planned at this level: capital investment, working capital, capital structure, and dividends. They therefore have constructed a model which uses as inputs many of the quantities which are the outputs of most financial statement generators: operating earnings and capital expenditures through time. CDD state that "Our model and a company's budget compiler can be though of in a hierarchial structure: top down policy model built upon the output of a bottom-up forecasting model."

Outputs from the model are major financial decisions over the planning period: dividends, working capital, and financing. Linear programming is used to simultaneously determine the values of all decision variables in all periods.

The inputs used in the model are composed of forecasts of the economic environment, legal restrictions and accounting relations, and management policy requirements. These input

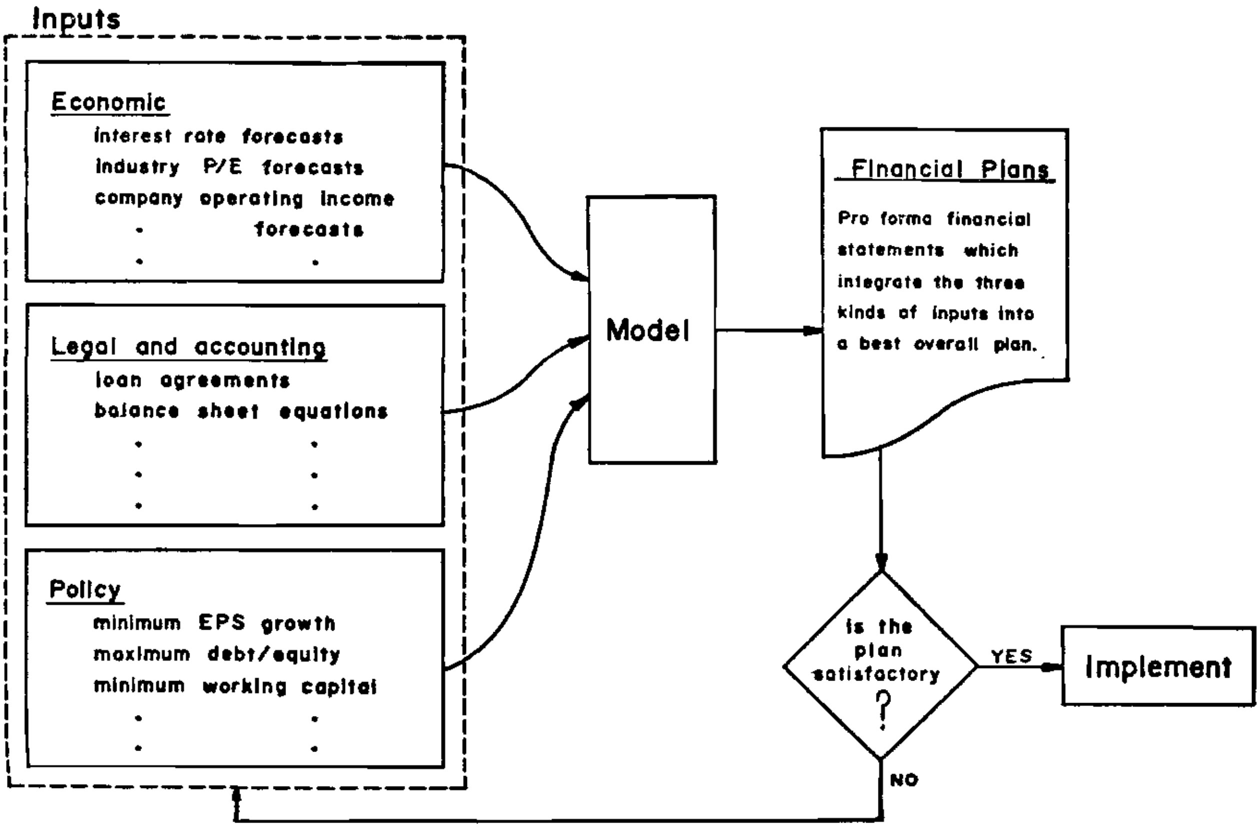


Figure 2.1. Structure of Optimizing Financial Planning Model

categories and examples of their content are shown in Figure 2.1. For a given set of assumptions regarding the economic environment, legal restrictions, and company policy, a "best" plan is produced.

The corporate objective usually used in the CDD model is that the "best" plan is the one which "...while staying within the limits permitted by the three kinds of inputs and given the cost of equity capital, makes the present value of owner equity as large as possible." This objective may be expressed as:

$$\text{Maximize:}\quad \frac{PV(0)}{N(0)} = \sum_{t=1}^{n} \frac{D(t)}{N(t)\prod_{\tau=1}^{t}(1+k_\tau)} + \frac{PV(n)}{N(n)\prod_{\tau=1}^{n}(1+k_\tau)} \qquad (2\text{-}1)$$

where

n = number of years in the planning period

$PV(0)$ = present value of owner equity

$PV(n)$ = horizon year value (derived in terms of forecasted posthorizon, or long-term opportunities)

$N(t)$ = number of shares outstanding in year t

k_τ = period τ forward cost of equity capital (input directly or derived from a series of questions about industry P/E ratios, etc.)

$D(t)$ = total dividend payment in year t

As can be seen from equation (2-1) above, this literal modeling of the expressed corporate objective results in a nonlinear objective function. This is because there are N(t) terms in the denominator, and these are part of the equity financing plan which is a model output.

This original objective function is linearized by suitable manipulations (as described by Komar, [34]) and is incorporated in the model as

$$\frac{PV(0)}{N(0)} = \sum_{t=1}^{n} a(t)\ D(t) + a(n)\ PV(n)$$

$$+ \sum_{t=1}^{n} b(t)\ Y(t) \qquad (2\text{-}2)$$

where a(t) and b(t) are fixed coefficients, and Y(t) = new equity in year t.

A similar modeling approach was taken at Boise Cascade, as described by Dickens [15]. The primary purpose for the construction of their model was:

- To forecast the optimal allocation of resources within the northwest operations of the Company given existing and anticipated raw material resources, existing manufacturing facilities, and market conditions as forecasted for the next fifteen years.
- To evaluate alternative investments in raw materials, plants and equipment under various economic assumptions and conditions over the fifteen year planning period.

As with the CDD model, the intended mode of usage for the Boise Cascade model was the determination of a "best" plan, given a particular input data configuration. The objective of the model was to maximize profits from the Company's Northwest operations. Inputs to the model include management forecasts of raw material availability, conversion (manufacturing) costs, product prices and "...technological innovation relative both to competitive substitutes for (the Company's) products and to process improvements which might reduce manufacturing costs and make currently unprofitable raw materials profitable to use."

Boise Cascade's Pacific Northwest Region is divided into nine "management units." The overall structure of their model is thus composed of an aggregation of nine individual subregion models. This structure is illustrated in Figure 2.2. One clear advantage of modeling each subregion individually is the special structure this imparts - facilitating the application of decomposition techniques. As shown, only five periods are used, with each period being three years in length. The linear programming model has 5,800 structural equations, 4,000 accounting equations, and 25,000 variables.

The specification of market forecast input for the model required that a forecast of the U.S. economic environment be made for the duration of the planning period. The Wharton Econometric model was used to provide this long-range forecast of the National economy. The specification of exogenous variables rested on "...presently stated economic and social goals of the Government" and the fiscal and monetary actions that these goals implied.

As mentioned above, the model is used in an iterative

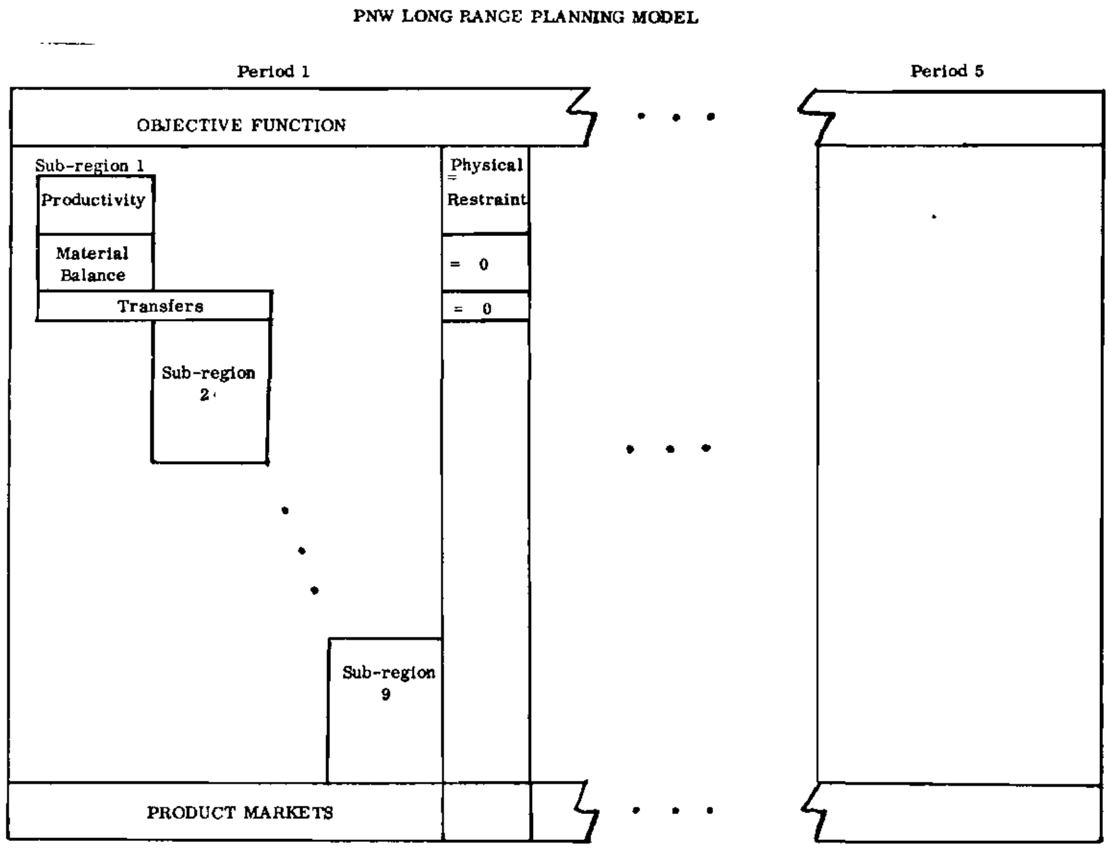


Figure 2.2. Schematic of Boise Cascade Linear Programming Model

fashion with assumptions, forecasts and constraints being changed on each run as desired. The results of each run are compared to a "Base Solution" to assess the impact of the changes. Answers are sought to questions such as:

What is the expected return on investment in a specific new facility (given optimum allocation of resources)?

Given a fixed supply of capital by time periods, and a number of investment alternatives, which investment or mix of investments adds most to the profits of the Company?

What impact do specified income requirements have upon existing and proposed investments?

What is the optimal rate for cutting timber over the fifteen year period?

Due to its formulation as an investment planning tool, the model does not lend itself to short-term operations planning (scheduling). However, as a result of experience gained with this model, Boise Cascade is developing more detailed models with more limited (regional or divisional) scope.

Many of the decisions faced by management both in business operations and planning, are of the "go/no-go" type. Such decisions must be represented by a decision variable which may assume values of zero or one. In order for linear programming to be applied to this kind of problem simplifying assumptions must be made to allow representation of naturally integer quantities by continuous variables. When one considers the fact that all business planning must, at least in part, be composed of decisions on whether or not to take a given action, the limitations imposed on model validity by the requirements of linear programming become apparent. This difficulty is exacerbated by the fact that "rounding off" of LP optimal solutions does not necessarily produce a solution which is even close to integer optimality.

These objections to the use of linear programming are the impetus for the use of mixed integer programming formulation by Hamilton and Moses [28] in constructing their model. They divide the decision variables used in the model into two categories: strategy variables and fund sources. The fund source variables are continuous, representing, respectively, the desired level of funding from long term debt (both general long-term debt, and that which is "tied" to specific projects), short-term debt, and issuance of common and preferred stock. The strategy variables are required to be zero/one integer variables, and are further divided into two groups: momentum strategies, which reflect continuation of present activities in current lines of business; and development strategies, which reflect proposed changes in the nature or level of present activities.

The general specifications for construction of the financial optimization model were:

1) Corporate scope. The model should reflect the full range of financial planning variables actually considered at the corporate level, including internal capital budgeting,

acquisition and divestment, debt creation and repayment, stock issue and repurchase, and dividend payout. A five to ten year planning horizon consisting of one-year planning periods was considered adequate.

2) Analytical requirements. Explicit provision should be made for evaluating discrete investments and extensive parametric variations in model inputs.

3) On-line operation. Direct access to the model and its data base should be possible via remote terminals to allow its most effective use as a creative planning tool.

4) Input/Output Flexibility. Alternative input and output options should be provided to facilitate model implementation for standard and special planning studies in both batch and interactive modes.

The authors state that the "...primary corporate objective was defined by management as maximizing the value of the corporation to its stockholders." This conceptual objective was converted to the more operational goal of maximizing earnings per share (EPS). Letting E_t be total corporate earnings in period t, and holding constant the number of shares of common stock at the level s_0 which prevails at t = 0, the multiperiod objective may be written as

$$\text{Maximize:} \qquad EPS = \sum_{t=1}^{T} E_{t/s_0} \tag{2-3}$$

which is linear and thus amenable to solution by available mixed integer programming codes. However, since the number of shares issued or repurchased in each period is an important part of the financing decision, the denominator of equation (2.3) becomes $s_t = s_0 + \sum_{\tau=1}^{t} \Delta s_\tau = s_{t-1} + \Delta s_{t1}$ where Δs_t is the change in the number of common shares outstanding in period t. This problem of a now fractional objective function is resolved in a manner similar to that used by Carlton, Dick and Downes [5]: the use of assumptions and manipulations appropriate to allow an objective function which is a linear approximation of (2.2).

The model has approximately 1000 variables and 750 constraints, not including upper and lower bound constraints. There are over 200 zero/one variables, including the abovementioned strategy variables and certain structural variables. The model is solved using a modified branch-and bound procedure, with total computation time (on a Univac 1108) of approximately 25-40 CPU minutes. Post-optimality analysis is available and consists of sensitivity analysis of continuous variables, parametric analysis, and case-study type variations in selected model input data and parameter values.

The model has been used in several areas of planning activity. In acquisition analysis, it has assisted in deciding not only what should be acquired, but also the timing of acquisition, and the proper method of financing. It has also been used to select general profiles of desirable acquisition candidates. Similar applications in divestment analysis have also been found. Its usefulness in evaluating policy restrictions has been shown by its illustration to management of the financial implications of contemplated policy decisions.

2.3 Financial Planning Models: Case Study/Simulation

Perhaps the most widely cited and best known exposition of a specific planning model is George Gershefski's paper concerning the Sun Oil Company model. This model is of the deterministic simulation variety, and represents the operation of the entire company. The inputs to the model include product prices and volumes, raw material costs, economic conditions, investments, subsiding company income, and discretionary expense items. Of 1,500 items required as inputs to the model, 500 are developed from historical information, and 1,000 are forecasts from operating departments. Additionally, certain fuctional relationships (e.g., that selling expense is a given linear function of variables such as the number of service stations, and gasoline sales) are estimated from historical data via the use of regression analysis. The model contains some 2,000 equations and produces 5,200 output items.

The equations in the model simulate the flow of oil from production at the well to refined product sales at the service station, the revenues and expenses associated with it, and the impact of capital investments on the volume of flow. Modular construction was used in creating the model, with "blocks" or subroutines being used to model selected aspects of the Company's operations. This approach to generating the model imparts not only flexibility, but also the ability for using the model before all desired features have been incorporated. In this regard, Gershefski cites the fact that, as of the writing of the paper, operations of subsidiaries enter only as bottom-line income projections. Because of its modular design, the model may be readily extended by the addition of "blocks" describing the subsidiaries' operations in more detail. Each block in the model takes into account the activities and alternatives associated with the operation being modeled, the relationship between cost and volume, and the accounting procedure followed. Connected via their modeled interrelationships, the block results are combined to produce consolidated net income for the Company. This block structure is illustrated in Figure 2.3. The model generates the following key reports:

Income statement

Capital investment schedule (by department)

Sources and uses of funds

Statement of earnings employed and stockholders' equity

Tax report (details adjustments required to reconcile book income with taxable income, etc.)

Rate-of-return analysis

Financial and operating summary

The financial and operating summary report highlights (1) financial items such as net income, revenue, total assets, long-term debt, return on stockholders' equity, and return on total assets employed; and (2) operational items such as crude oil

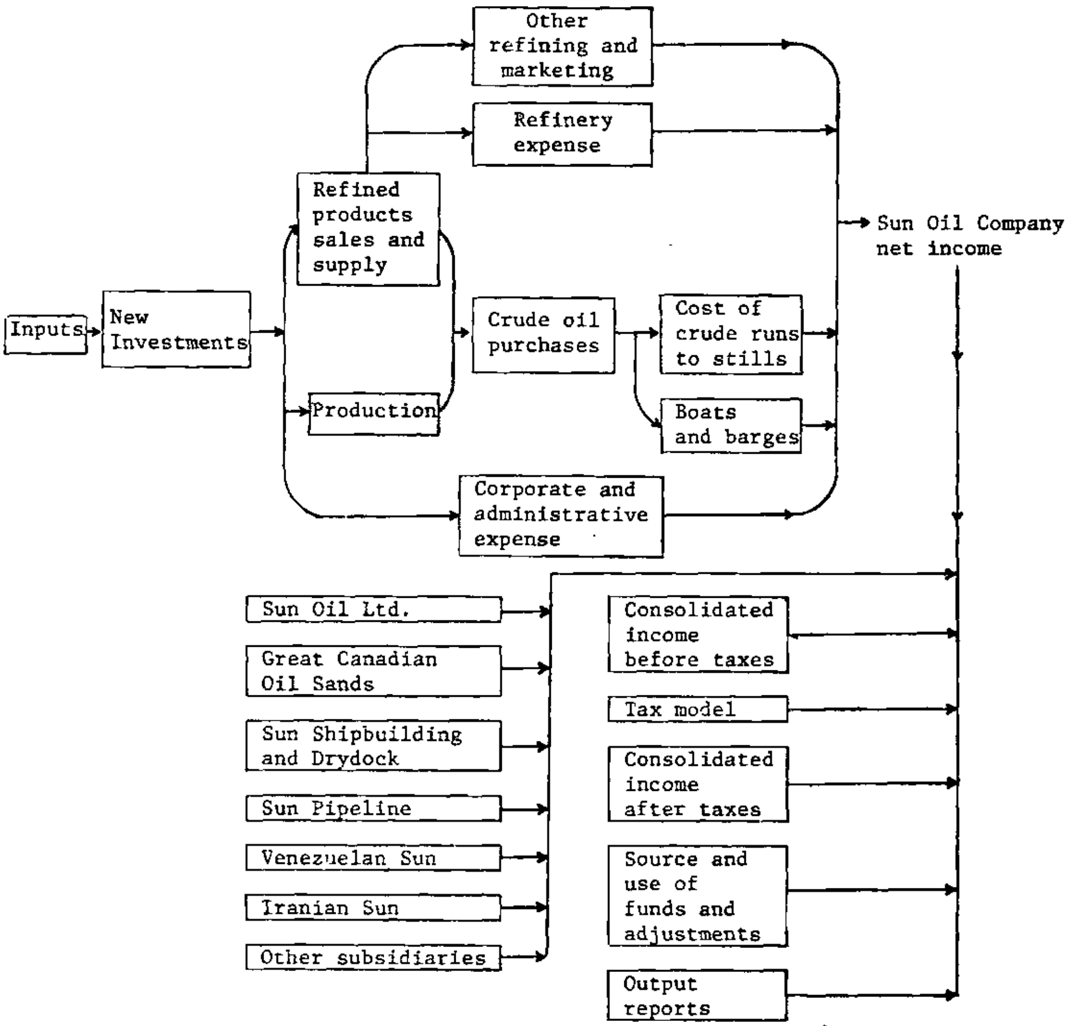


FIGURE 2.3

SUN OIL FINANCIAL MODEL FLOW CHART

produced, crude oil to be run in refineries, the level of crude oil revenues, gasoline sales, and market share. Including supporting schedules, the total model output consists of 142 pages and 61 specific reports. Working capital is not as yet modeled in detail, so a full balance sheet is not produced.

The model is run using batch submittal of input. To facilitate the comparison of alternatives in the case-study approach, several runs can be submitted at one time. Once an initial input configuration has been specified, subsequent runs require input of data and/or parameter changes only. The exact form and content of model reporting is controlled by a report writing program that retrieves selected information from computer storage.

A model which explores the synthesis of economic theory and business decision making has been created by C.W. Burrill and Leon Quinto of the IBM Systems Research Institute [4]. The simulation model was designed primarily as a tool for research and education in the area of finance. Because of this focus, the authors concentrated on the detailed modeling of the financial aspects of business activity, with less effort being directed toward the operating areas. To be of maximal usefulness as a tool for the illustration of the usefulness of planning models in a business environment, the model was formed with simplicity of structure in mind. Additionally, output from the model is in conventional accounting form where possible.

The computer model is based on the operations of a hypothetical company which produces a single product. This product (which is, coincidentally, computing equipment) is both sold and leased. In the context of the model, this leads to two sets of demand functions - one each for lease and outright purchase - which must reflect the interdependencies between sale and rental pricing and overall demand.

The assumption is made that demand can grow rapidly over time. The company may meet this demand by expansion of production facilities, taking into account opposing forces of inflation and technological improvement. Financing of expansion can be achieved by the "usual means", including the flotation of stock and bonds. The rate of interest on borrowed funds is generated by the model as a function of a "modified" debt-equity ratio. Market valuation of stock is determined as a function of previous years' earnings and the book value of the company.

The model determines plant capacity as a function of (user supplied) expenditures for plant and equipment in previous years. Like the modeling of the demand equations, the equations which yield manufacturing costs are based on economic theory. As plant capacity is increased, the minimum average cost of production decreases, while the production level necessary to experience this minimum cost increases.

Simulation is carried out over a variable planning period, with one year time units being used. Typical planning horizons are 5 or 10 years. Important model input and output quantities are highlighted below.

Input

1) Planning period length

2) Product purchase and lease prices (annually)

3) Quantity to be produced (annually)

4) Capital expansion schedule (annually)

5) Financing amount and mix (annually)

Output

1) Annual balance sheets, income statements, sources and uses of funds, and certain key financial ratios.

2) Marginal cost, marginal revenue, backlog, inventory, and selling price per share of common stock (annually)

The intended mode of model use is in the answering of "what if" type of question via variation in input factors. No internal optimization is performed, although external routines have been created which generate inputs needed by the model so as to effect local suboptimization of certain company activities. No stochastic elements are included in the model, primarily to allow for ease of understanding on the part of students using it.

Burrill has found the model to be very useful in both teaching and research activities. In the latter regard, he presents an example of the usefulness of the simulation approach in addressing complex questions of intertemporal allocation of investment resources. Results were achieved by using directed simulation study to verify and refine algorithmic constructs and simplified closed form relationships drawn from theories of economics and finance.

A careful treatment of the human element in model design has been presented by Stone, Downes and Magee (SDM) [61]. Their discussion is based on a conversational financial statement simulator built for General Recreation, Inc.. The model allows for both short and long term planning, allowing for both individual consideration of these two aspects of the planning process, or a simultaneous consideration via iteration between these two model sections [60].

SDM present simple data generation functions which are intended to reduce the user's data entry burden, while at the same time permitting flexibility in specification of model elements and interrelations. They have been incorporated into a model which does not comprise a set of fixed account types or classes. Rather, it approaches a simulation language in that the user may specify report titles, account names, and the method by which the account variables are to take their values. The possible functional relationships available for account value specification are included in a "menu" of account generating functions which is supplied as part of model documentation, and is reproduced (in part) in Table 2.1. The authors cite some benefits which they feel accrue from the use of the approach:

1) A reduction in the data entry burden from that required for specification of an entire schedule of account values.
2) Limitation of knowledge required to that normally possessed by a person engaged in business planning.

Table 2.1 Basic Account Generation Functions

Function Name	Number	Parameters 1	2	3	4	Structure
Proportional Growth	1	--	G1	T	L	$NAME_t = (1+G1)^{L/T}\ NAME$
Dollar Growth	2	--	G2	T	L	$NAME_t = NAME_{t-L} + G2(L/T)$
Linear Proportion	3	SEC	B	P	L	$NAME_t = B + P \cdot SEC_{t-L}$
Moving Ratio	4	SEC	--	--	L	$NAME_t = NAME_{t-L}\ (SEC_t/SEC_{t-L})$
Sum - Difference	5	Parameters are names and signs of secondary accounts.				$NAME_t = \pm\ SEC1_t \pm SEC2_t$ ....
Period-By-Period	6	--	--	--	--	User specification of individual data.

G1 = percentage growth rate

G2 = dollar growth rate

T = growth compounding time

L = lag time

B = base amount

$Name_t$ = value of primary (dependent) account at time t

SEC_t = value of secondary (independent) account at time t

P = proportionality factor

-- = no parameter required

3) The ability to perform sensitivity analyses by changing only a few parameters instead of large blocks of user-entered data.

4) The fact that the concepts of growth rates, ratios, and proportionality factors are those typically used in planning practice. Thus the specification of a specific modeling situation is couched in terms that are familiar to the user.

The basic generation functions shown in Table 2.1 are extended and enriched by the incorporation of additional types of generating capability: time dependent data generation functions, varying growth and varying proportion. The manner in which these additional capabilities are provided is best described by use of an example. Suppose that a company has sales which grow at an annual rate of 10% with a lag time of 6 months. Using a time unit of one month, T=12, and the appropriate account generation function would be Function Number 1 in the following form:

$$\text{SALES}_t = (1.10)^{1/2}\ \text{SALES}_{t-6}$$

In the use of the SDM model, entry of this relationship would be as follows (user input underlined):

```
TYPE ACCOUNT NAME, FUNCTION NO: 0 = STOP
*SALES,1
TYPE PARAMETERS:  G1,T,1
*0.10,12,6
```

If company planners instead believed the companies sales to follow a proportional growth rate pattern which varied over time, only a slight change in model data entry is required. Adopting the convention that time periods need only be specified when one is specifying more than one function or set of parameter values, and letting (m,n) denote that a given function or parameter set is to be used in periods m through n, this situation may be handled in a straightforward manner. For growth of 10% in months 1 through 6, and 7% thereafter, the following user-model dialogue would take place.

```
TYPE ACCOUNT NAME, FUNCTION NO: 0 = STOP
*SALES,1
TYPE G1,T,L
*0.10,12,6(1,6),0.07,126
```

Sensitivity analysis is carried out by the comparison of "versions" or complete sets of information necessary to project future financial statements. In addition to comparison by inspection on the part of the user, the model possesses the capability for creation of common-size and exception reporting.

The authors note that there are some types of interdependencies which embody sufficient complexity so as not to be amenable to account by account specification. They utilize the notion of a "special subsystem" which refers to "...preprogrammed components of the financial statement generator that find jointly consistent values for groups of interdependent accounts."[1] They cite as examples of subsystems of this type: financing, depreciation and tax. In addition, certain special attributes of a particular company's financial activities (e.g., seasonally extreme levels of accounts receivable) may mandate the creation of company-specific subsystems to render modeling efforts sufficiently useful in the planning process.

2.4 Planning Languages

Discussion of planning languages PROPHIT II [49] and PSG II [48] begins with a summary of some of their common characteristics. Once this common ground has been established, some features unique to each are presented. Finally, this section concludes with the FAPS [18] program product.

As used here, a planning language is distinguished from a planning model by the degree of flexibility inherent in its use. The range of commands available and the freedom to design the mechanics of report generation and display are such that the user, in effect, builds his own model. Through appropriate specification, company-specific practicies may be incorporated, and particularly relevant reports generated. The raison d'etre for the development of these languages was to provide this capability to the planner/user within an environment where computer programming skills were not required. Rather than becoming embroiled in the details of a

1 An example of such a subsystem which controls the cash management function may be found in Stone [60].

general programming language, the user works with a set of commands and options which apply exclusively to the planning process.

PROPHIT II is part of a library of business oriented software[1], and as such, its capabilities are enhanced by the ability to access other library components. Although probabilistic considerations may be incorporated into a given user model, PROPHIT II is basically oriented toward deterministic comparison and evaluation of alternative scenarios: "A prime benefit of PROPHIT II is that its flexibility and speed enable management to examine the effects of many more changes and to investigate more alternatives." This system is used in an interactive setting and is, in its simplest form, a "computerized columnar spread sheet." Figure 2.4 shows the basic data flow involved in user specification of a model. The "definition file" contains the operations necessary for model construction. The "data file" provides input quantities to be run according to instructions in the definition file, as controlled by PROPHIT II commands. A report file is generated so that subsequent analysis can be carried out on the model-generated data without the necessity for recomputation. In actual use, the user inputs an "Operation Code" which defines the function to be used, placing after it parameters and line numbers as necessary[2].

---

1 "CALL/370 Business Information Services for Planning, Analysis and Control," marketed by the Service Bureau Company.

2 The reader will note the similarity between this form of input and the "menu" of account generation functions used by Stone et al. [61].

HAND-PREPARED SPREAD SHEET

	1ST Q	2ND Q	3RD Q	4TH Q
SALES	3000	3750	5500	5000
COST OF GOODS SOLD				
LABOR	775	950	1500	1200
PACKAGING	300	375	550	500
INGREDIENTS	725	850	1100	960
TOTAL C.O.G.S.	1800	2175	3150	2650
GROSS MARGIN	1200	1575	2350	2350

DEFINITION FILE (MODEL)†

```
 (1) SALES                READ LINE OF DATA
 (2)                      SKIP BLANK LINE
 (3) COST OF GOODS SOLD   PRINT TITLE ONLY
 (4)    LABOR             READ LINE OF DATA
 (5)    PACKAGING         .10 X LINE (1)
 (6)    INGREDIENTS       READ LINE OF DATA
 (7)                      UNDERSCORE COLUMNS
 (8) TOTAL C.O.G.S.       SUM LINES (4),(5),(6)
 (9)                      SKIP BLANK LINE
(10) GROSS MARGIN         SUM LINES (1),-(8)
```

DATA FILE†

```
PRODUCT A; QUARTERLY COLUMNS
(1) 3000, 3750, 5500, 5000
(4)  775,  950, 1500, 1200
(6)  725,  850, 1100,  950
```

PROPHIT II COMMANDS†

```
RUN **PROPHIT2
COMMAND...................? CREATE
 DEFINITION, DATA NAMES...? MODEL, DATA
COMMAND...................? PRINT
 REPORT FILE NAME.........? REPORT1
 WHICH COLUMNS............? ALL
 WHICH LINES..............? ALL
```

REPORT

PRODUCT A

	1976 1ST Q	1976 2ND Q	1976 3RD Q	1976 4TH Q
SALES	3000	3750	5500	5000
COST OF GOODS SOLD				
LABOR	775	950	1500	1200
PACKAGING	300	375	550	500
INGREDIENTS	725	850	1100	950
TOTAL C.O.G.S.	1800	2175	3150	2650
GROSS MARGIN	1200	1575	2350	2350

REPORT FILE

Basic Data Flow – Often, a single model can handle many data files, each of which represents a specific product line, branch office, division, etc.

†Stylized for presenting initial concepts.

Figure 2.4. PROPHIT II Basic Data Flow

The vocabulary of data manipulative commands which are a part of PROPHIT II include special report functions to combine, or extract and compare, separate sets of data. In addition, there exists a "WHAT-IF" command which provides the capability for assessing, in a straightforward manner, the effects of changes in selected data or modeled relationships.

PSG II is a planning language designed for use via batch submittal of punched card decks. It provides the user with "transparent" data management capabilities such as data conversion and storage which are, in large part, the same as those underlying the operation of PROPHIT II as described above. The user provides PSG II with the logic necessary to generated desired information. These instructions consist of FORTRAN statements. All input and output operations are controlled by PSG II, thus the user need only be concerned with specification of logic and functional relationships.

In addition to a library of "planning functions" (e.g., for computation of compound growth rates) PSG II also allows the user to create FORTRAN language subroutines to model special items. Indeed, the user logic specifications are supplied to PSG II in the form of subroutines also.

The Financial Analysis and Planning System (FAPS) is not a planning language <u>per se</u>, in the sense that the user does not create his own model. Instead, it is a conversational, time-sharing model composed of a package of generally applicable subsystems. On-Line Decisions, Inc., the firm which markets the model, constructs a "User Company Model" after a study of the operations of the company purchasing their service. The macro structure of FAPS is shown in Figure 2.5. The Strategy and Planning and Evaluation (SPE) and Integrated Data Analysis (IDA) subsystems concern themselves, respectively, with pro forma financial performance, and evaluation of past and present operations. They are integrated so that data from one subsystem can be used as input to the other. FAPS is designed as a tool to enhance the decision making process via the answering of what-if questions and does not contain optimization code.

2.5 Small Business Models

A "Profit-Planning and Control System" (PPCS) has been developed by Kick [32] which is designed for use by a small business. The PPCS is a combination of prescribed management analysis activities, culminating in the provision of input to a simulation model. A profit planning subsystem and profit control subsystem compose the PPCS. The first of these generates a pro forma income statement, balance sheet, and statement of financial analysis for a "forecasted year." The profit control subsystem produces fifteen reports similar to those produced by the planning subsystem. The statement of financial analysis in the profit control subsystem compares industry figures for the current year with actual and projected performance of the firm being studied. Table 2.2 contains sample output from each of these subsystems.

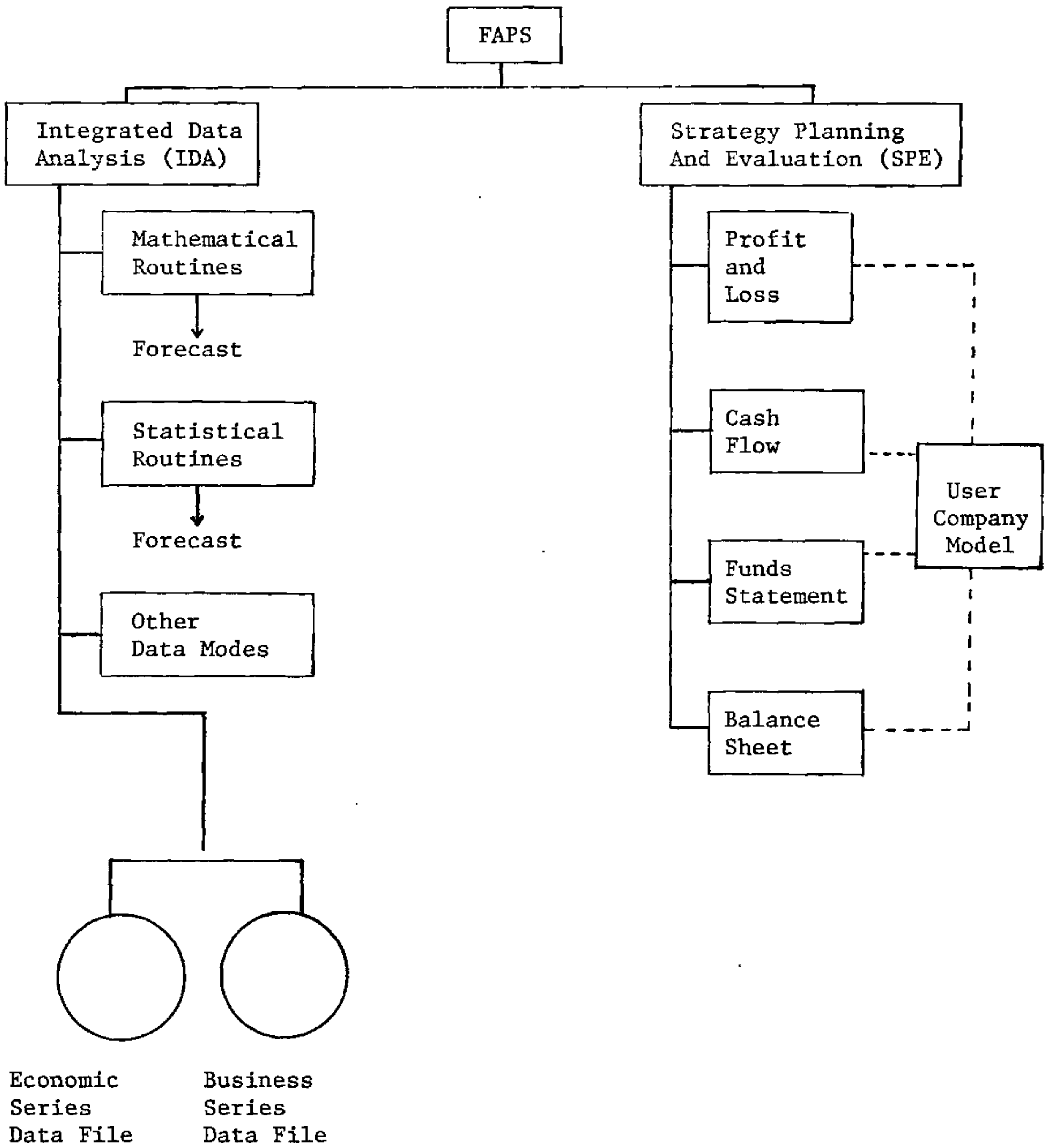


FIGURE 2.5

FINANCIAL ANALYSIS AND PLANNING SYSTEM

Table 2.2 PPCS Output

PLANNING SUBSYSTEM OUTPUT

PROFORMA
INCOME STATEMENT
DECEMBER 31, 19XX

	MOST RECENT YEAR	FORECASTED YEAR	PERCENT CHANGE
SALES	3;036,000	3,160,000	4.1
COST OF GOODS SOLD	825,000	900,000	9.1
GROSS PROFIT	2,211,000	2,260,000	2.2
SELLING EXPENSE	1,002,760	996,000	—0.1
ADMINISTRATIVE EXPENSE	770,800	790,000	2.5
DEPRECIATION EXPENSE	120,000	120,000	0.0
TOTAL EXPENSES	1,893,560	1,906,000	0.1
NET OPERATING PROFIT	317,440	354,000	11.5
INTEREST EXPENSE	10,240	14,000	36.7
NET INCOME BEFORE TAXES	307,200	340,000	10.7
FEDERAL INCOME TAXES	153,600	170,000	10.7
NET INCOME AFTER TAXES	153,600	170,000	10.7

CONTROL SUBSYSTEM OUTPUT

STATEMENT OF FINANCIAL ANALYSIS

DECEMBER 31, 19XX

	INDUSTRY	ACTUAL	PROJECTED
CURRENT RATIO	2.8	2.2	2.4
QUICK RATIO	1.6	1.1	1.3
LEVERAGE	.5	.5	.5
TIMES INT EARNED	13.2	12.8	13.0
INVENTORY TURNOVER	6.5	5.5	5.5
AVE COLLECTION PERIOD	40 DAYS	48 DAYS	46 DAYS
FIXED ASSET TURNOVER	1.6	1.5	1.6
PROFIT MARGIN	.05	.03	.05
RETURN ON ASSETS	.06	.05	.05
RETURN ON EQUITY	.15	.12	.12
EARNINGS PER SHARE	3.00	2.50	3.00
BOOK VALUE PER SHARE	22.50	20.00	24.00

A flow chart of the planning subsystem is provided in Figure 2.6. The upper portion of this chart represents the series of management actions which are necessary before effective use can be made of the computer model. The decisions and assumptions that are a result of this process provide the input to the model, as shown in the lower portion of Figure 2.6. The input characterizations provided in the flow chart are the extent to which Kick described model input. It may be inferred from the purely financial output of the subsystem that these inputs are composed of projected flow of financial resources, and related information. The model itself is a "...financial simulation of the company, the purpose of which is to produce a set of pro forma statements representing the status of the firm at the end of the planning period."

The author suggests that the model may be re-run with different inputs if the initial results of simulation are unsatisfactory. He states that to facilitate use of models of this type by small businessmen, "regional data processing centers" should be established by either the Small Business Administration or private organizations. Model input could be sent to these centers either in written form or in machine readable media, or the model could be accessed via a remote time-sharing terminal.

The apparent forerunner of the PPCS was the Small Business Information System (SMALBIS) which was developed by Kick and H-C Chen [8]. The characteristics of this model are essentially the same as those of the PPCS, as shown in the summary of model

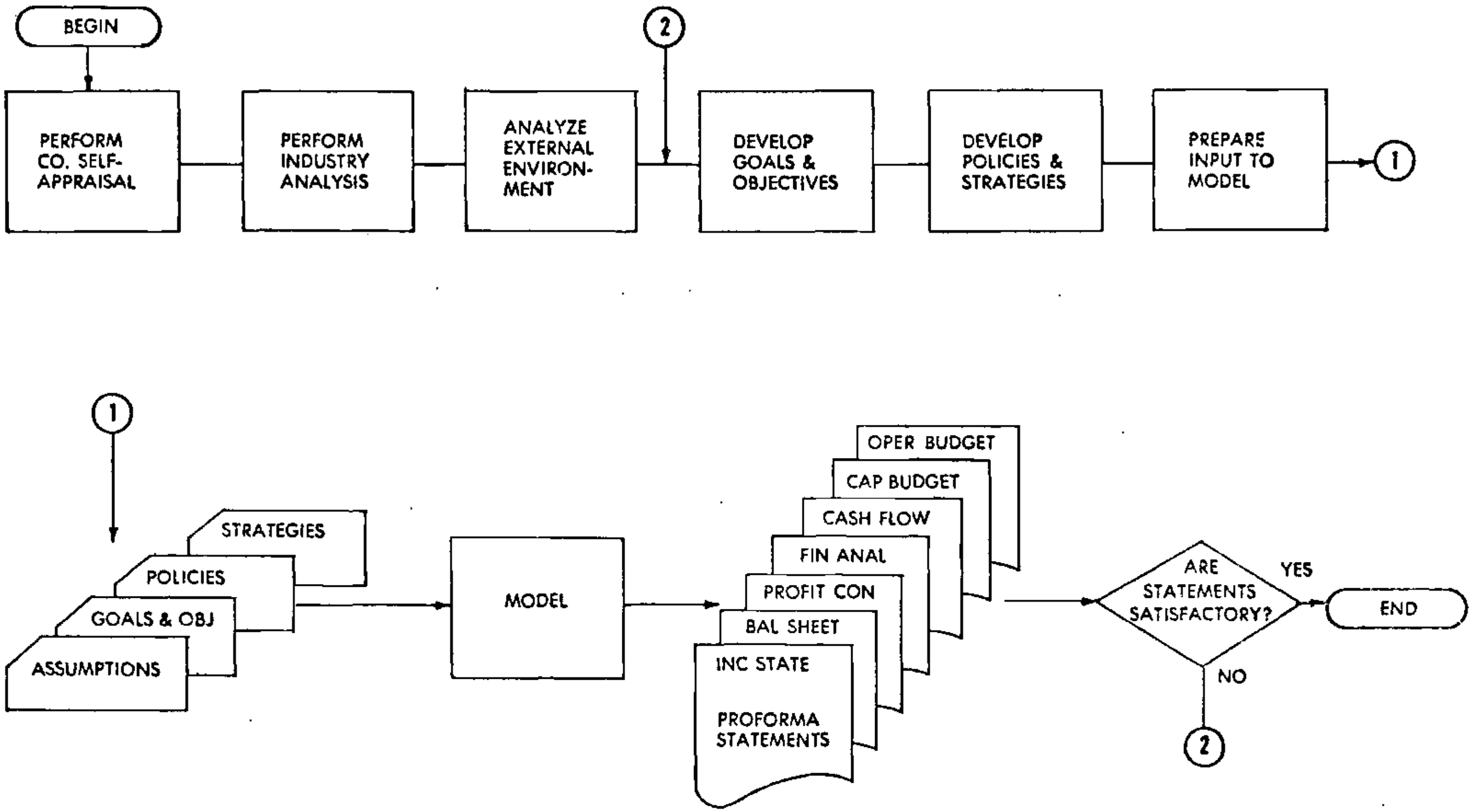


Figure 2.6. Components of the Planning Process

characteristics found at the end of this chapter. SMALBIS is composed of two subsystems: the planning subsystem and the reporting subsystem. It may either be operated in the planning mode via the use of forecasted data, or in the accounting system mode. The latter mode is utilized by inputting actual data which is used in the generation of normal accounting forms. Input to the model consists of:

1) Initial values for the financial data base.
2) Definitions of routine accounting transactions.
3) Decision tables to relate transactions to the data base.
4) Projected or actual transactions (depending on mode to be used).

Items one through three above relate to the key elements of model structure: the use of the matrix accounting technique. The data base is organized as a matrix, with each element of the matrix corresponding to a particular account (or other data base item). This structure is shown in Figure 2.7. Each item in the data base may be accessed by a row and column address. A third dimension is added to allow for data to be stored which corresponds to different years as shown in Figure 2.8.

Individual transaction types are identified by a code and related to the data base items by a decision table which contains information regarding the accounts which are affected by each transaction type, and the sign associated with this effect. Thus,

	REVENUE AND EXPENSE ACCOUNTS	ASSET ACCOUNTS	LIABILITY AND EQUITY ACCOUNTS	FUND ITEMS	BUDGET UNIT ITEMS
SALES	X				
COST OF GOODS SOLD	X				
SELLING EXP.	X				
ADM. EXP.	X				
FEDERAL TAXES	X				
CASH		X			
ACCTS. REC.		X			
INVENTORIES		X			
LAND		X			
BUILDINGS		X			
DEPRECIATION		X			
ACCTS. PAYABLE			X		
LONG-TERM DEBT			X		
COMMON STOCK			X		
RETAINED EARNINGS			X		
INC. IN LONG-TERM DEBT				X	
SALE OF PROPERTY				X	
PAYMENT OF DEBT				X	
INC. IN INVENTORIES				X	
DEPT. A REVENUES					X
DEPT. A COST OF GOODS SOLD					X
DEPT. C COST OF GOODS SOLD					X
DEPT. C PAYROLL EXP.					X
DEPT. C SUPPLIES					X
DEPT. C EQUIPMENT					X

Figure 2.7. Matrix Data Base Concept

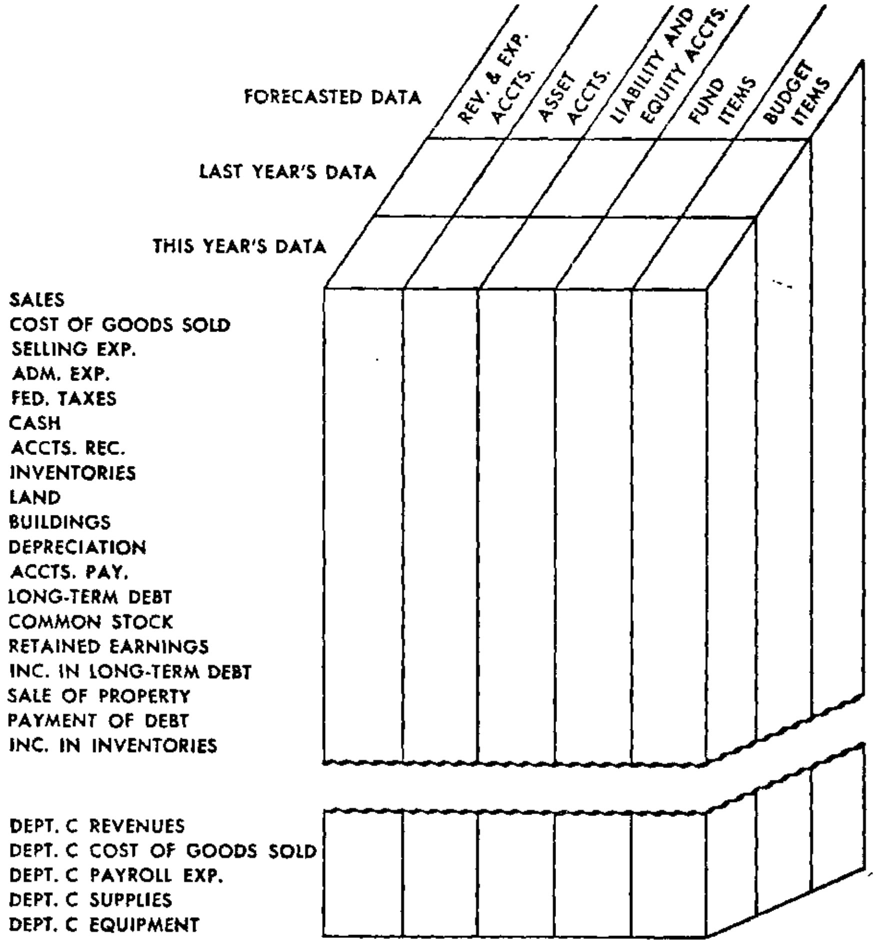


Figure 2.8. Expanded Matrix Data Base Concept

once a transaction has been identified by a code, only two pieces of information are required to update the data base. Additional data regarding transaction date and reference would be needed for accounting and reporting purposes.

This updating process is illustrated in Figure 2.9. A cash sale increases the Sales row in the Revenue and Expense column, Net Income in the Funds column, and Revenue for Department C in the Budget column. Similar updating activities, as dictated by the input decision tables, are shown for a purchase on account and a bank loan. Normal double entry methods are used to handle special transactions not included in the tables.

The model is run in the planning mode (using forecasted transactions) in an iterative fashion until a satisfactory scenario is created. These forecasts then are incorporated into the data base in the form of monthly data on the upcoming year. During this next year the model may be run in the accounting mode, using the forecasts from the previous year and transactions in the current year to generate various exception reports and financial statements. This information is very useful for control purposes.

The operations of a small machine tool manufacturing firm have been modeled by DesJardins and Lee [13]. The firm, which has annual sales of about $12 million, produces ten basic models of machine tools. The majority of the orders it receives call for special modifications of one of these models. Because of this, the production process consists of a job shop which produces

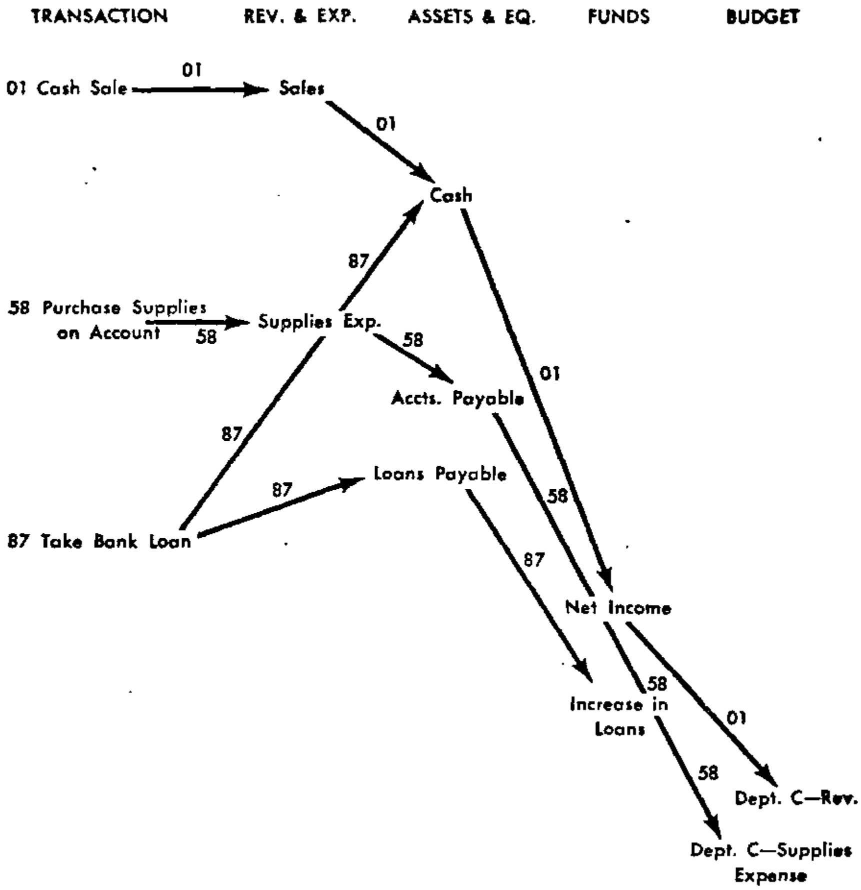


Figure 2.9. Transactions - Data Base Concept

parts for inventory, and an assembly operation which assembles tools for customer specifications.

The flow of material in the firm is illustrated schematically in Figure 2.10. Incoming raw materials are inspected and placed in storage. They then go through the manufacturing process, which consists of five machine centers and an inspection operation. Each part must go through one or more operations, and all parts must pass through inspection. Once a part has been inspected, it is placed in a finished parts storage area. For the assembly operation, parts are moved to the assembly area, where they are assembled, tested, and placed in finished goods storage to await shipment.

For purposes of modeling, the firm was considered to be a set of modules structured into an "Operational System." The Operational System is composed of four subsystems: the Materials System, the Manpower System, the Financial System, and the Capital Equipment System. Each subsystem is in turn composed of several modules which represent specific functions or tasks within the firm. This general model structure is illustrated in Figure 2.11. This modular structure treats the interdependencies between functions, although this is not shown in the Figure. The underlying mode of model operation is to "...simulate the physical flow of materials, cash, and information within the firm." This attention to the details of the actual operation of the firm can best be illustrated by closer examination of one of the model subsystems. The Materials System is selected for this

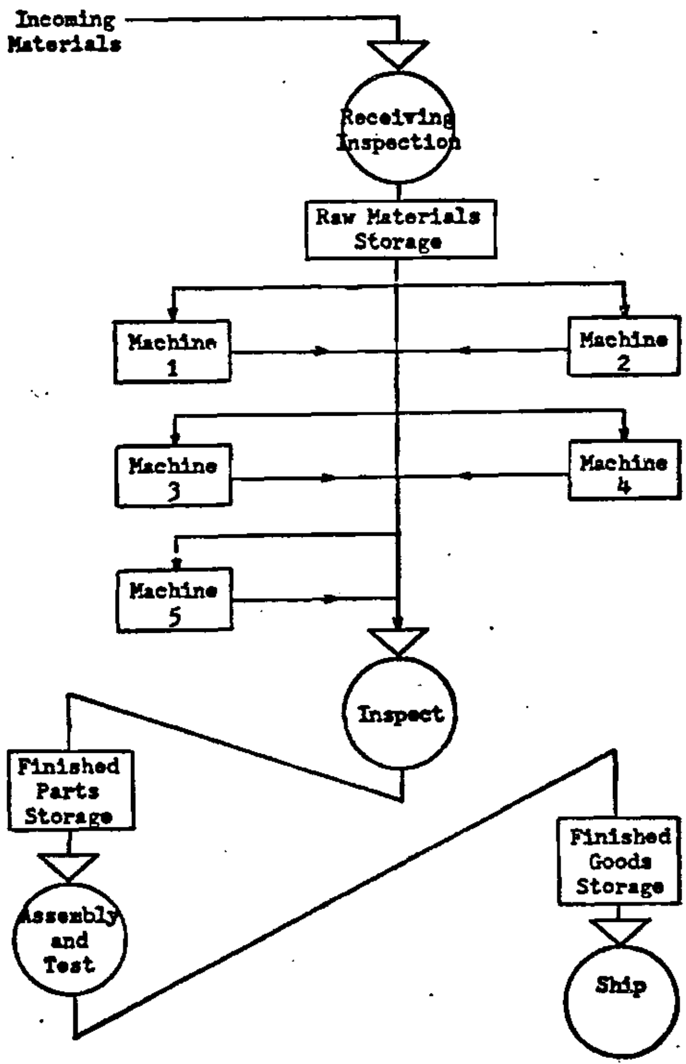


Figure 2.10. Materials Flow

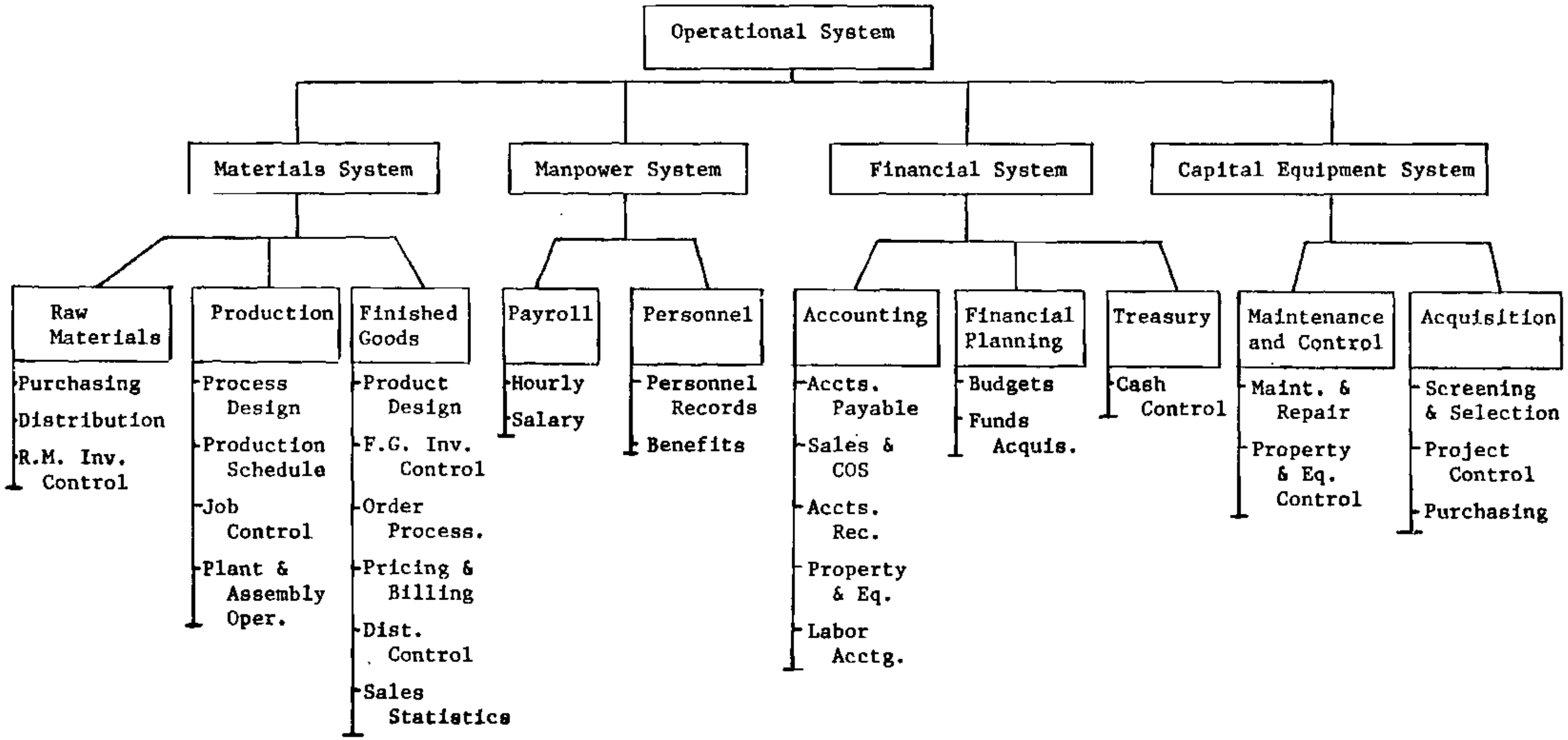


FIGURE 2.11 OPERATIONAL SYSTEM

purpose because of its particular relevance to the present thesis work.

The Materials System, as modeled, represents the network of material flow through the production process. Included in it are the Finished Goods, Production, and Raw Materials modules. The functions contained in each of these system modules are shown in Figure 2.11.

A flow chart of the finished goods system is given in Figure 2.12. The workings of this module are described below.

> The process is begun with the receipt of a new order from a district sales office. If the order requires engineering design or interpretation, it is routed to the product design group. When pricing and scheduling is completed, a confirmation of the order is sent to the district sales office. The sales statistics group provides to the finished goods control function short term forecasts based on sales history, on raw forecasts from the district sales offices, and on predetermined forecasting parameters. The finished goods control group then combines these forecasts with actual orders already entered and provides to production scheduling the requirements. In turn, they receive from production scheduling the actual schedules of production which can be used to schedule future orders and to answer inquiries about product availability. At the scheduled shipping date, if the product is available, shipping instructions are sent to the distribution control function which, in turn, ships the product and sends shipping papers for billing.

The new order generation process is stochastic, and simulates (1) the number of orders arriving each month, and (2) for each order, the item ordered, the order quantity, and the requested delivery date. The size of the queue of orders waiting to be filled is a result of the system capacity, the volume of orders, and the stochastically assigned processing time associated with each incoming order. The remainder of the finished goods module is composed

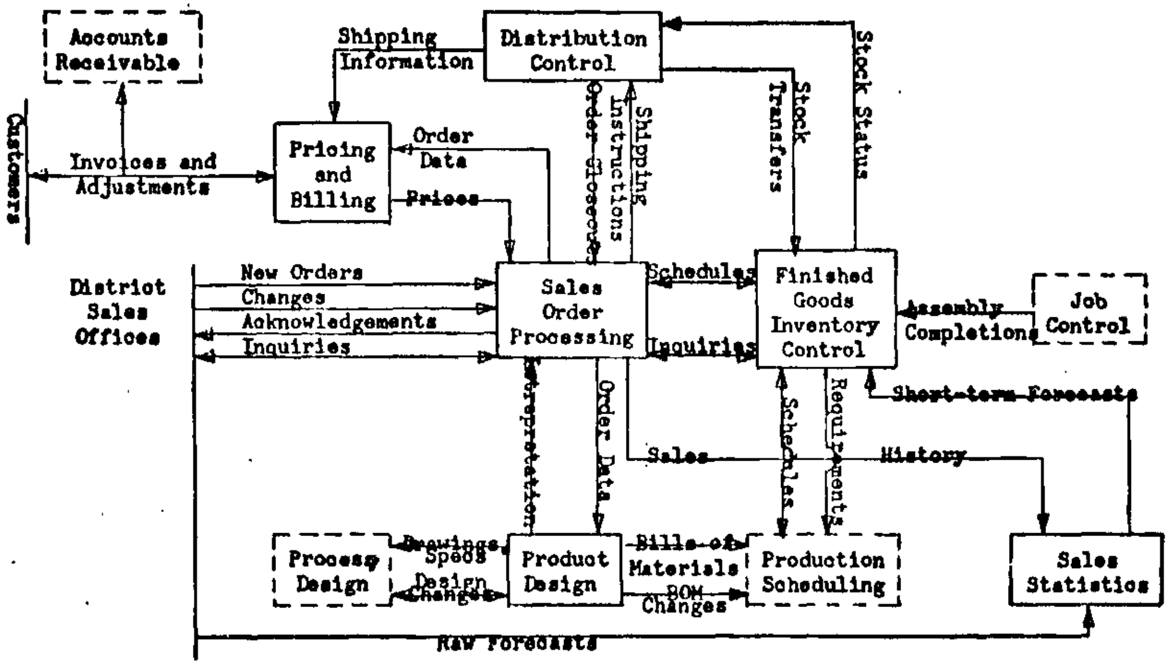


Figure 2.12. Finished Goods System

of deterministic quantities.

The activities of the production module (Figure 2.13) are initiated by receipt of product requirements from the finished goods module. Based on these requirements, product assembly and parts products are planned, and raw materials requirements are determined. Requests for raw materials go to the raw materials and inventory control function. Parts production and product assembly requirements are sent to the job control function in the form of shop orders or assembly orders.

There is a queue associated with each operation in the production process. The time that a given job remains in the queue depends on the capacity of the operation, the priority associated with the job, and the processing times of the jobs ahead of it in the queue. The job control functions creates job orders, which act to put requisite raw materials into production, and remain with the part throughout processing. Upon completion of the inspection operation, the part is placed in storage and the completed job order is used to signal the closing of the open job order file.

The finished machine tools which need to be assembled, and thus the parts needed for assembly are determined in the finished goods module. However, due to limitations on availability of specific parts and the possibility that finished good demand may exceed assembly capacity, assembly of all desired items may not be possible. For this reason a linear programming routine is used

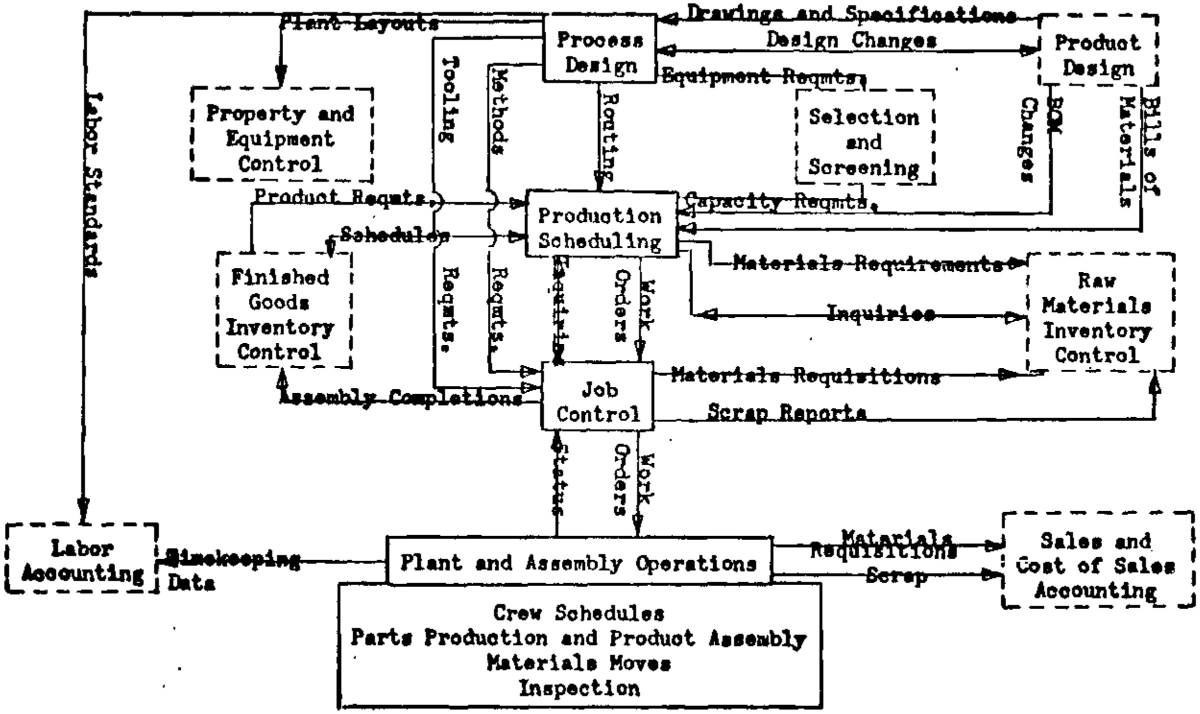


Figure 2.13. Production System

to determine which tools will be assembled in a given month. The actual time required for assembly is a stochastic variable, and there exists a queue of orders waiting for assembly.

During the processing of each order, data is kept on the time required for each operation performed. This information is used to monitor job status, and for labor accounting and determination of incentive earnings.

The Raw Materials System is flow charted in Figure 2.14. Materials requirements are determined in the production scheduling function and communicated to raw materials inventory control. This function compares these requirements with the extant inventory position and computes quantities and delivery dates for needed purchases. Receipts of raw materials are handled by the distribution function which closes out open purchase order files and updates raw materials inventory records.

As is evident from the foregoing presentation, the Materials System consists of a precise simulation of the flow of individual orders through the firm. The generation of demand is presumably modeled with stochastic processes based on historic data and management judgement. Productive capacity and the associated level of staffing may be adjusted during a run by the Capital Equipment System. The Manpower System is simply a record keeping function which determines the various kinds of compensation to be received by each employee and maintains current data regarding each employee.

Cost data generated by model modules is accumulated and

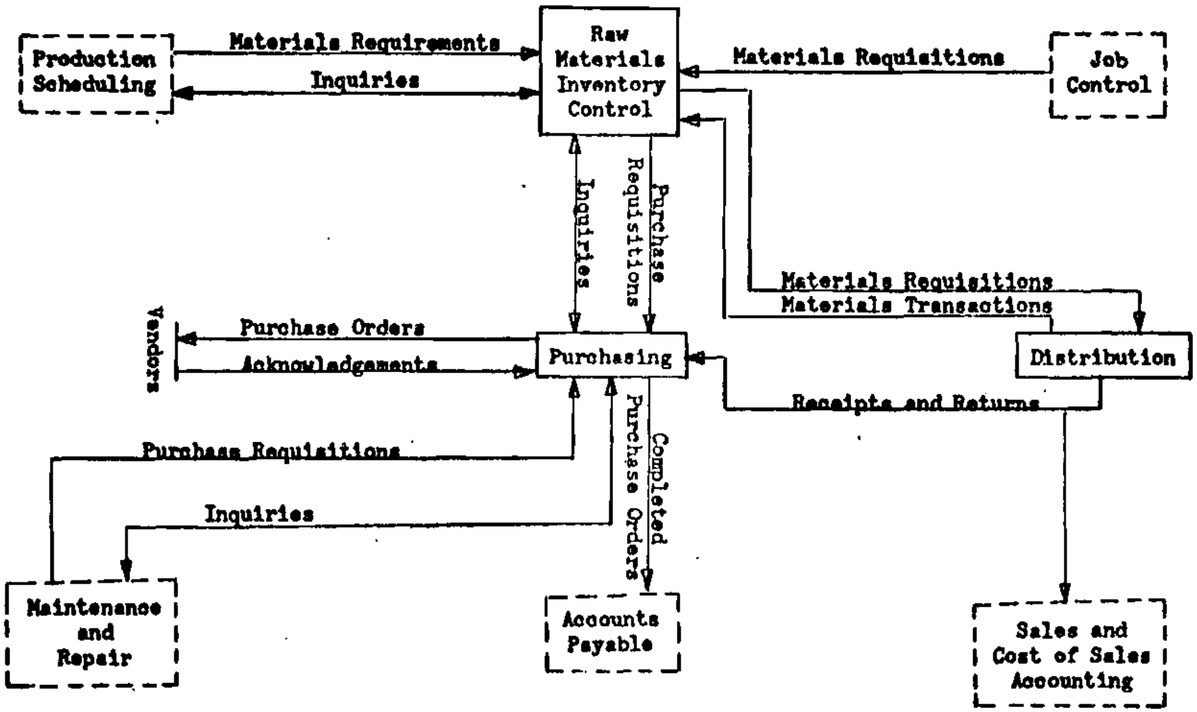


Figure 2.14. Raw Materials System

processed by the accounting module of the Financial System. Cash control is performed by the treasury module, with the determination of funds requirements and sources being carried out in the financial planning system.

The model has been found by DesJardins and Lee to be useful in four specific situations:

1) Capacity Planning -- timing of plant expansion and capital equipment purchase.
2) Budgeting -- testing alternative budgets for the coming years.
3) Inventory Planning -- testing alternative strategies for reducing inventory.
4) Aggregate Production Planning -- planning aggregate levels of work force and production.

In all of these instances, the common problem, and hence an indicator of model usefulness, has been the interrelationships which exist among independent variables and their effect on profit.

2.6 Manufacturing Company Models

A systems approach is taken in the design of a linear (programming) planning model by Baker and Damon [1]. They seek to treat the company and its activities as a single entity comprising a single set of component parts. This differs from other approaches by other authors in that they are typically delineated along functional lines. As in a real-world business situation, functioning of a whole-company model is usually achieved via interaction between model components along specified channels of communication. Satisfactory global solutions are determined subsequent to iteration between model components along specified channels of communication. Satisfactory global solutions are determined subsequent to iteration between model components. As an example, we look at linear formulations of models for determining production plans and levels of working capital.

Several varying models of aggregate planning of production output for a firm facing seasonal demand have been put forth and are cited by Baker and Damon. They present a synthesis of these formulations which embodies the principle elements of the approaches taken. This linear formulation is presented below, with the underlying assumptions and variable descriptions appearing in Table 2.3.

$$\text{Minimize} \sum_{t=1}^{N} (pWF_t + cRP_t + (c+o)\ OP_t + hIN_t + aH_t + bF_t)$$

s.t.

$$IN_t = IN_{t-1} + RP_t + OP_t - S_t \qquad t \in [1,N]$$

$$WF_t - WF_{t-1} = H_t - F_t \qquad t \in [1,N]$$

$$RP_t \leq \alpha\ WF_t \qquad t \in [1,N]$$

$$OP_t \leq \beta\ WF_t \qquad t \in [1,N]$$

Table 2.3 Aggregate Production Planning Model

ASSUMPTIONS

1. The product line is sufficiently homogeneous so that aggregate planning reasonably can ignore differences among products.

2. Sales forecasts are reliable. The firm's policy is to meet all demand without backlogging.

3. Equipment and technology are the limiting factors in determining production outputs at normal workforce levels. The labor market is perfectly competitive in the relevant range.

VARIABLES

Decision Variables:

- workforce level during month t (WF_t)
- regular time production output, in dollars, in month t (RP_t)
- overtime production output, in dollars, in month t (OP_t)
- inventory level, in dollars, at the end of month t (IN_t)
- employees hired at the start of month t (H_t)
- employees fired at the start of month t (F_t)

MODEL PARAMETERS

- month index ($t=1,2,\ldots,N$)
- dollar sales in month t (S_t)
- technological limit on workforce size (m)

Table 2.3 cont'd.

- productivity in dollars of output per employee per month (α)
- overtime productivity in dollars of output per employee per month (β)

COST COMPONENTS

- regular time monthly payroll cost per employee (p)
- nonlabor production cost per output dollar (c)
- overtime payroll cost per output dollar (o)
- out-of-pocket inventory holding cost per dollar per month (h)
- hiring cost per employee (a)
- firing cost per employee (b)

production and sales plans provide homogeneous inputs to the pro-forma statements. Under the assumptions listed above, end-of-month payables correspond to nonlabor costs of production in the month. An expression for the accounting identity which relates the right and left side of the balance sheet is

$$CA_t + AR_t + IN_t + PE_t = AP_t + LO_t + AT_t + SE_t + RE_t \quad (2\text{-}4)$$

In this expression, loan outstanding is derived as the balancing equipment. The other variables are first predicted, and then the loan amount required to achieve balance is computed. If the required loan is prohibitive, reformulation of the other components of the

where

$$0 \leq WF_t \leq m \quad \text{and} \quad RP_t,\ OP_t,\ IN_t,\ N_t,\ F_t \geq 0$$

Given a sales forecast (S_t) and initial workforce and inventory levels (WF_0 and IN_0), solution of the linear program produces a set of levels for regular time and overtime outputs, monthly inventory, and workforce[1]. In a real world setting, these outputs would be transmitted to finance department personnel who would create budgets and schedules needed for planning of operations. Cash management and determination of working capital needs would evolve short-term borrowing and credit line determination. It may occur that, due to factors in the firms external environment, the optimal production plan is proven infeasible and adjustments of financing and production must take place in an iterative fashion.

If we view the determination of working capital and short-term credit from the point of view of the cash manager, we need to construct pro forma income statements and balance sheets. The assumptions underlying this construction and the variable definitions used are shown in Table 2.4. In addition, net cash flows are used as the basis for income tax computation. If we measure production output in units of sales dollars, then the

---
[1] The model assumes homogeneity of labor (implicit in the perfectly competitive labor market assumption). It could be extended to accommodate differing labor types, j, j=1,2,...,J by adding to the dimensionality of certain variables: WF_{jt}, N_{jt}, F_{jt}, α_j, β_j, p_j, o_j, a_j, and b_j.

Table 2.4. Specification of Financial Variables

ASSUMPTIONS

1. All payables and receivables are paid off within the following month (i.e., with a scrupulous adherence to payment terms of net 30 days).

2. The firm has no marketable securities and generally ignores short-term investment opportunities.

3. Interest payments on the loan outstanding are made at the end of the month. The monthly interest rate is denoted i.

4. Taxes are paid at the end of the year on net income. The corporate tax rate is denoted r.

VARIABLES

Net Income

- Sales (S)
- Cost of Goods Sold (CGS)
- Fixed Overhead Charges (OH)
- Gross Profit (GP=S-CGS-OH)
- Taxes (TX=rGP)
- Net Earnings (NE=GP-TX=(1-r)GP)

Balance Sheet

Assets	Liabilities
Cash (CA)	Accounts Payable (AP)
Accounts Receivable (AR)	Loans Outstanding (LO)
Inventory (IN)	Accrued Taxes (AT)
Plant and Equipment (PE)	Stockholder's Equity (SE)
	Retained Earnings (RE)

balance sheet, and hence the activities from which they result must be effected.

Baker and Damon suggest a formulation that captures the interdependence of these two planning functions in a single set of equations. This simultaneous model is linear, due to the assumptions used in construction of the production planning equations, and the inherent linearity of the cash planning relationships. Separating the components of production cost, the net cash flows from operations in month t is

$$CF_t = AR_{t-1} - AP_{t-1} - pWF_t - oOP_t - hIN_t - iLO_t - aH_t - bF_t - OH_t$$

where under the assumptions about the planning environment,

$$AR_{t-1} = S_{t-1} \text{ and } AP_{t-1} = c(RP_{t-1} + OP_{t-1})$$

Since the cash position of the firm is affected by cash flow as well as change in the loan amount, we can write

$$CA_t - CA_{t-1} = CF_t + (LO_t - LO_{t-1}) \qquad (2\text{-}5)$$

The authors make the assumption that the firm maintains a constant production function by exactly replacing depreciated equipment with new equipment, and thus achieve correct values of all income statements and balance sheet entries without explicitly treating depreciations. The monthly increment in accrued taxes can then be modeled as

$$AT_t - AT_{t-1} = rCF_t = r(CA_t - CA_{t-1} - LO_t + LO_{t-1}) \qquad (2\text{-}6)$$

By adding relationships (2-4), (2-5), and (2-6) (after substitutions noted above), to the production planning model described earlier, the single model is constructed as shown below. The criterion used is maximizing the net profit of the firm, as represented by the maximization of retained earnings in the last month of the planning period, RE_N.

Criterion

Maximize RE_N

Production Constraints

$$IN_t - IN_{t-1} - RP_t - OP_t + S_t = 0$$

$$WF_t - WF_{t-1} - H_t + F_t = 0$$

$$RP_t - \alpha WF_t \leq 0$$

$$OP_t - \beta WF_t \leq 0$$

Financial Constraints

$$CA_t - CA_{t-1} - S_{t-1} + cRP_{t-1} + cOP_{t-1} + pWF_t + oOP_t + hIN_t$$

$$-(1-i)\ LO_t + LO_{t-1} + aH_t + bF_t + OH_t = 0$$

$$AT_t - AT_{t-1} - rCA_t + rCA_{t-1} + rLO_t - rLO_{t-1} = 0$$

$$CA_t + S_t + IN_t + PE - cRP_t - cOP_t - LO_t - AT_t - SE - RE_t = 0$$

Bounds on Decision Variables

$$0 \leq WF_t \leq m$$

$$0 \leq LO_t \leq \ell$$

If it is assumed that taxes are paid only once, at the end of the planning period, and that there is a minimum cash amount, L, required as a buffer stock, then

$$CA_t - L \geq 0$$

and

$$CA_N - AT_N - L \geq 0$$

Finally,

$$AT_t \quad , \quad RE_t \text{ unrestricted,}$$

and all other variables ≥ 0

The bound placed on workforce size is a limitation based on the capacity of extant plant and equipment. Relaxation of this bound via parametric analysis would be useful in evaluating the economic value of expansion of facilities, at least in terms of the impact on current year profits. Similarly, sensitivity analysis could be used to evaluate the desirability of expansion of existing credit limits. In cases where either of these constraints are binding, examination of shadow prices associated with these constraints would reveal the marginal increase in retained earnings resulting from a unit constraint relation. Thus the advisability of borrowing for expansion of facilities and/or working capital could be determined via comparison of these marginal returns against the marginal cost of additional borrowing.

An example of a company-specific model which combines treatment of manufacturing and financial activities is provided by Harrison and Baker [27]. Their discussion is based on their experience at the National Coal Board (Great Britain) and is specifically concerned with modeling done in the Coal Products Division (CPD). CPD is the process arm of the National Coal Board, and is concerned with the commerical exploitation of coal derivatives and some related ancillary ventures. It is a wholly owned subsidiary, with its own Board of Directors, and is a large decentralized firm in its own right. It operates three main businesses, managed in five groups with an aggregate annual net income of 100 million pounds on a capital investment of 60 million pounds. It is further characterized as "growing fast" particularly in the area of offshore exploration.

The impetus for model building arose from three main problem areas.

1) Forecasting and budgeting for individual plants in the short term. Manual preparation of this information for one year periods required six months to complete and thus was generally out of date and unstable.

2) Medium and long-term business planning. Formal and organized procedures did not exist for the kind of planning needed for rational investment of capital. A 20 year outlook was needed on:

   i). The coal supply position - where can raw materials be obtained?

   ii). The market position - to whom is which product to be sold and at what price? The main requirements in this setting were the need to ask speculative, judgement forming "what-if" questions -- and to do so in an expeditious manner.

3) In the context of the negotiation of various contracts and bids, to quickly generate information necessary for negotiation of price clauses, price review periods, and discount rates.

Rather than set up a simple large model embracing all requisite interdependencies at once, it was decided to provide middle management with models tailored to fit their specific needs. The reasoning underlying this decision was the excessive time required to set up a model of the size that would be necessary, and its inflexibility in response to environmental and corporate changes. What evolved was a system of models at three levels:

1) Numerous small interactive programs used by local plant staff dealing with such matters as quality control and plant safety. Similar models are used by CPD Corporate staff for activities such as evaluation of wage increase proposals, and cash flow appraisals for capital investment projects.
2) Short-term planning and budgeting models at the plant level.
3) The "Corporate Model" which deals with CPD as a single entity.

An overview of a typical short-term (coking) plant modeling capability is shown in Figure 2.15.

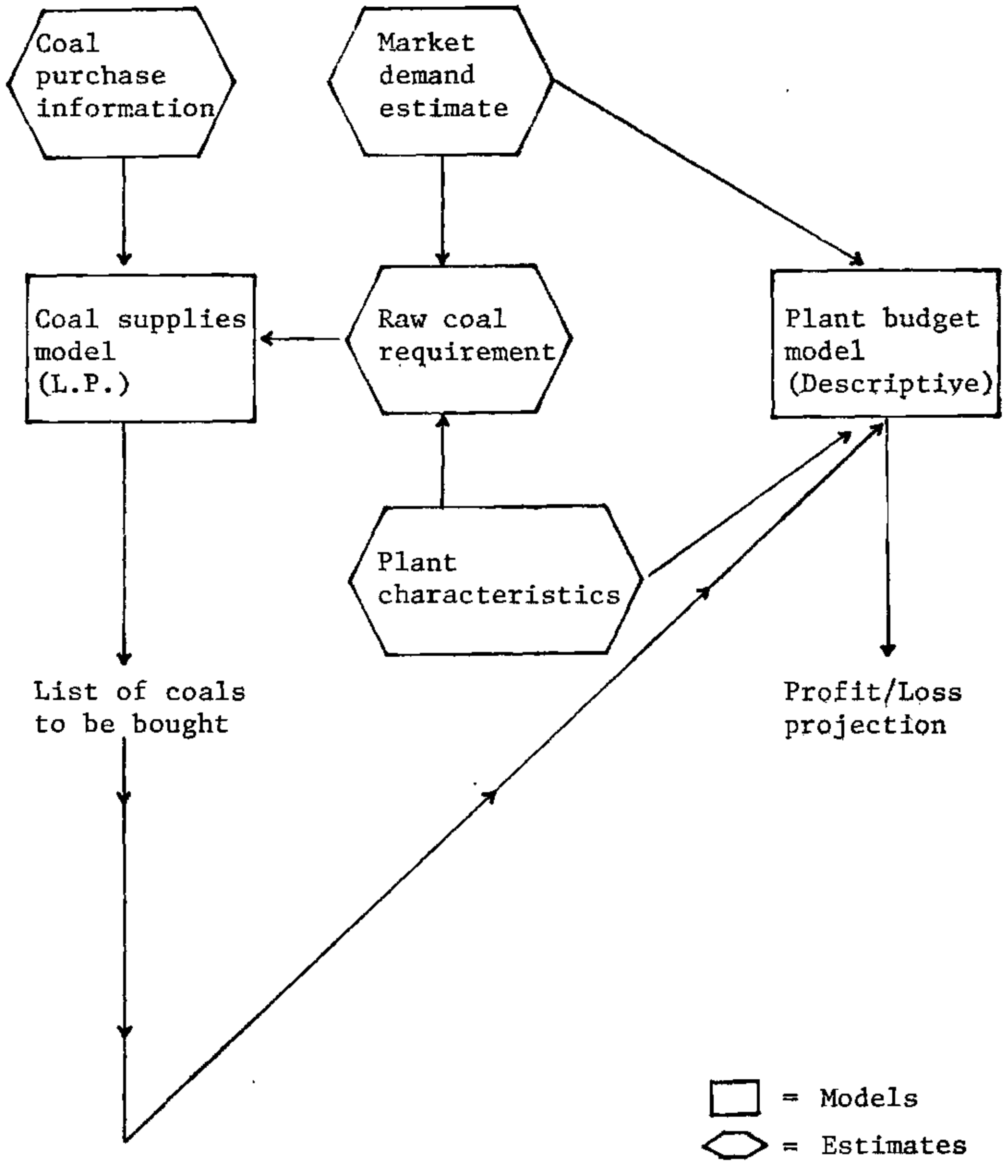


FIGURE 2.15

SHORT TERM PLANNING/CONTROL MODELS

The "Coal Supplies Model" is a linear programming formulation which determines the optimal feed coal of desired quality at the least cost. The constraints are provided by the main measures of input material quality: content in the coal of ash, sulphur, volatile matter, moisture, and a swelling index measuring the volume change as the coal is carbonized. Considerable use has been made of this sort of model in evaluating the trade-off between more stringent quality requirements and coal blend cost.

The function of the "Plant Model" is to relate planned plant production policy and demand forecasts for different kinds of coke to resultant plant revenues and costs. Its principle output is a profit and loss statement. No cash flow is produced, since all financing is done on a Corporate level. The structure of the linkage between plant operations and its profit and loss results is shown in Figure 2.16. The stages of the model are:

- Analysis of the planned operating policies to produce the yield of product.
- Matching production/marketing levels to give sales and stock levels.
- Build up of operating costs relative to operating policy.
- Stock value adjustments (accounting "provisions") to guard against loss of realizable value owing to deterioration of product line, etc.
- Presentation of results in stock change tables and profit and loss statements.

* Chief Variables

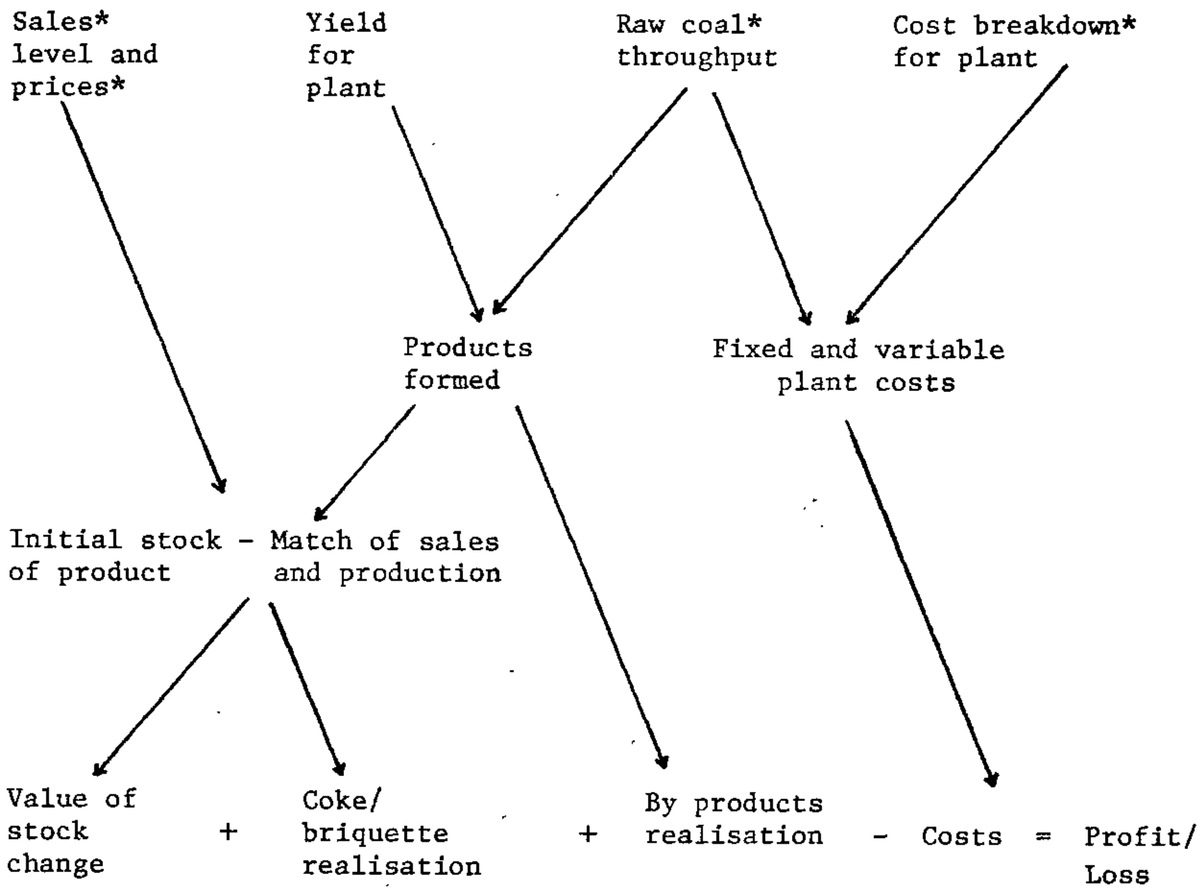


FIGURE 2.16

OUTLINE OF A SIMPLE PLANT MODEL

The relationships of some 93 plant variables are modeled through use of chemical engineering formulae, accounting relationships, and equations formed from the evaluation of historical operating data.

Figure 2.17 illustrates the components of planning models on the Corporate level which are long term -- on the order of 2-15 years. Decisions made in this timeframe concern the nature and timing of coke oven rebuilding and retirement to meet varying levels of demand. These decisions in turn interact with the availability of coking coal to individual plants. The "Demand Prediction" and "Coal Supplies" models are forecasting models relying on input market research data. The "Corporate Model" has the following properties:

> It ...evaluates a suggested national CPD production policy (which includes rebuilding plants and converting individual plants to produce other types of coke) against demand estimates for products. The model can cover up to 25 years and includes physical summaries of production and pattern of supply to individual geographical markets. The results from the corporate model show the financial consequences of possible policies both in terms of profit and loss and of cash requirements.

An illustration of the logic of the Corporate model is given in Figure 2.18. The logic is essentially similar to that of the Plant Budget Model, with two important differences. First, since the Corporation must be concerned with acquisition of funds, a cash flow statement is produced. The second difference is the added complexity represented by a matching process which must go on between generated plant production levels and supply and demand markets on a national, whole-company

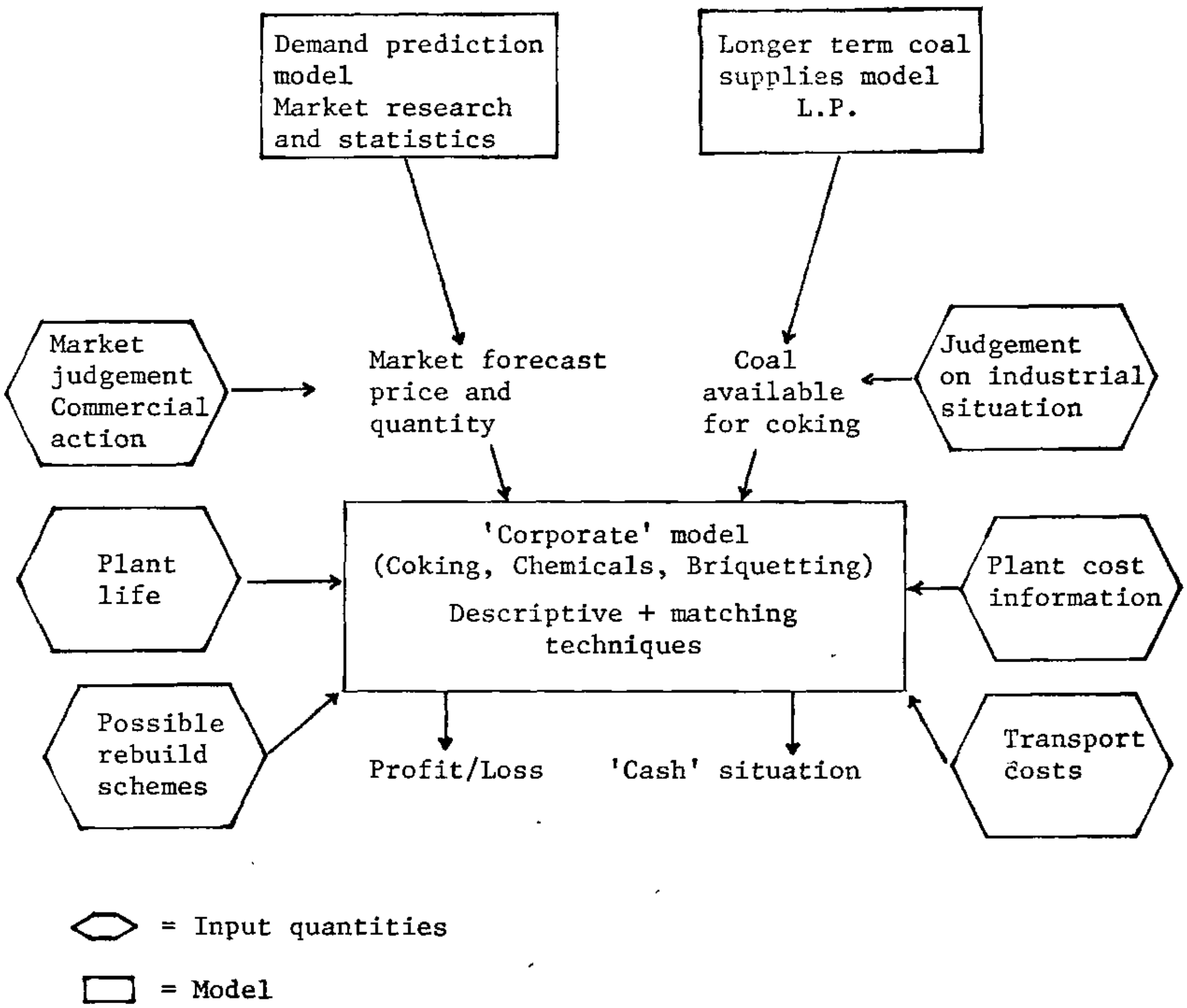
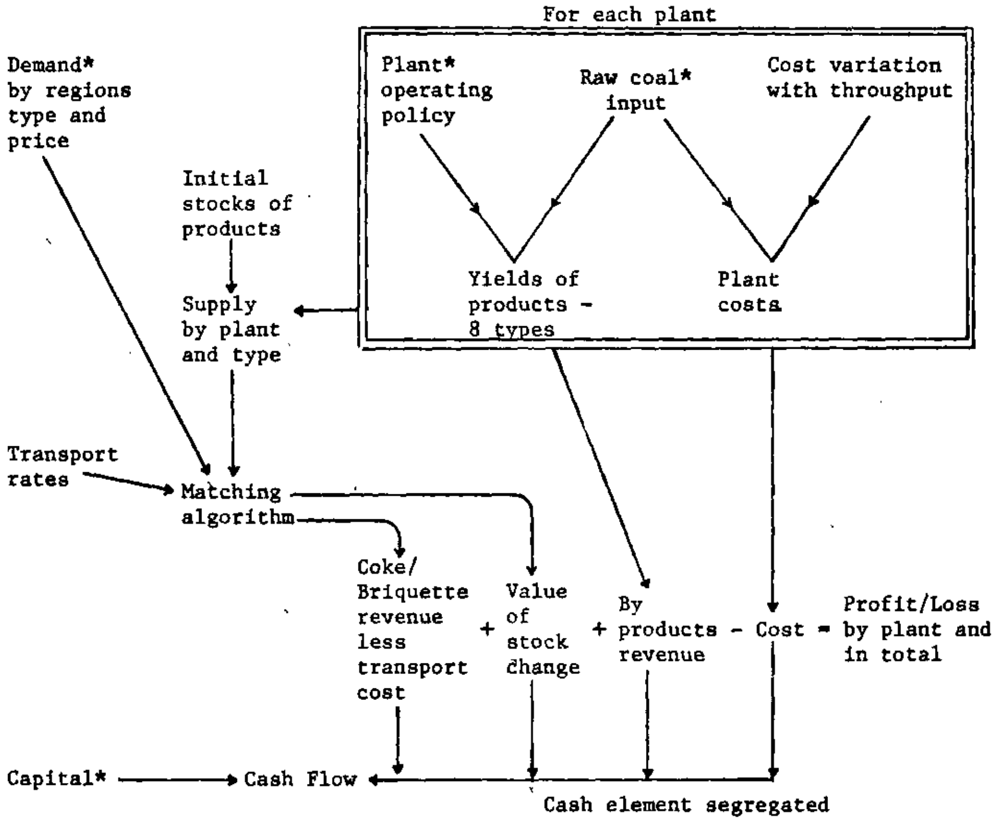


FIGURE 2.17

LONGER TERM PLANNING MODELS



* Chief quantities to be varied.

FIGURE 2.18

CORPORATE MODEL LOGIC

basis. The approach taken in this regard is the maximization of the sum of the individual plants' "financial contribution" (price less production and transport costs).

Harrison and Baker cite the following benefits which have resulted from modeling work at CPD.

1) Illustration to plant and staff management of the interrelationships between the plants' activities.
2) The ability at all levels to examine a permutation of alternative scenarios.
3) Speed of reaction in contract negotiation settings. Computer modeling permits immediate evaluation of an opponent's proposal and the generation of feasible counter proposals in a short enough time to beneficially impact upon the competitive bidding activity.

As at CPD, at Corning Glass Works (CGW) the decision was made to initiate modeling efforts via the development of separate, relatively small models, rather than by creating a single model of large-scale proportions and complexity [6]. The grounds for this decision were essentially those experienced in the previous example: development time, and lack of flexibility. Further indications of the desirability of creating several smaller models were the reliance of CGW on new product introduction for continued growth, and the benefits to be obtained from allowing the human element to be the bridge between what would otherwise be component parts of a single model. This last aspect embodies the identification of the need for managerial understanding of (at least) overall methodology employed by a quantitative model before acceptance reaches the level required for significant use.

Chambers, Mullick, and Smith (CMS) [6], describe the major model types that have been developed by CGW since the mid 1960's. These are:

1) Financial Planning
2) Multi-national Investment
3) Econometric Simulation
4) New Product Planning

For purposes of providing background for the thesis research described hereinbelow, it is most useful to concentrate on the New Product Planning Model. This model is itself composed of five different modeling techniques or approaches:

1) A disaggregated marketing model
2) A project control system (or CPM) for tracking and warning purposes.
3) A plant location model
4) A short-term production and capacity planning model
5) A venture risk analysis model (long term)

Each of these models (Figure 2.19) interact with one another in the sense that the information which is used for planning purposes is obtained via the iterative exchange of information between all of the models. The lines in Figure 2.19 indicate flows of

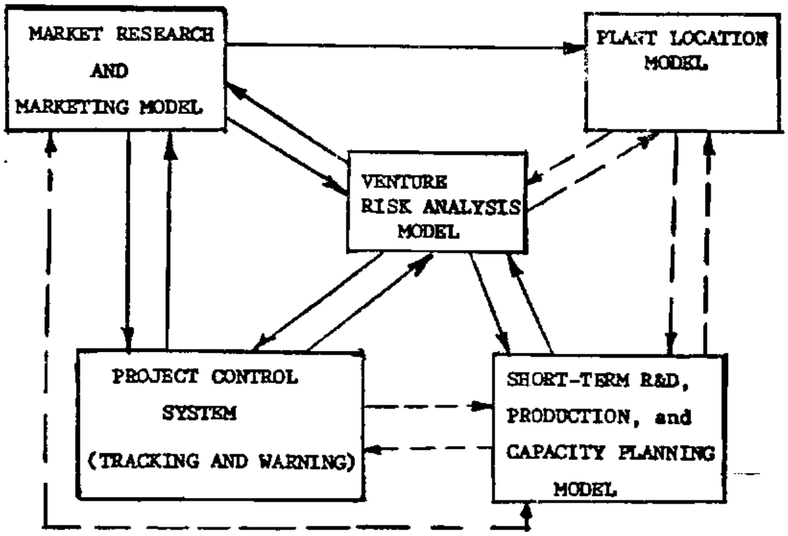


Figure 2.19. Interactions of New Product Planning Models

information; with solid lines indicating direct transfers of data, and dotted lines representing "indirect" information flows.

An illustration of the means by which this interaction took place is provided in Figure 2.20 which shows the long term risk analysis model. An integral part of this model is the generation of detailed manufacturing cost information, which, if one adheres to the above classification of model components, comes from the manufacturing model. In the framework of the evaluation of risk, the short-term production and capacity model is used to provide the abovementioned cost data for a given configuration of plants; as determined by the marketing, plant location, and risk analysis models. Given varying inputs of these types, the production model provides a range of manufacturing cost figures for use as input

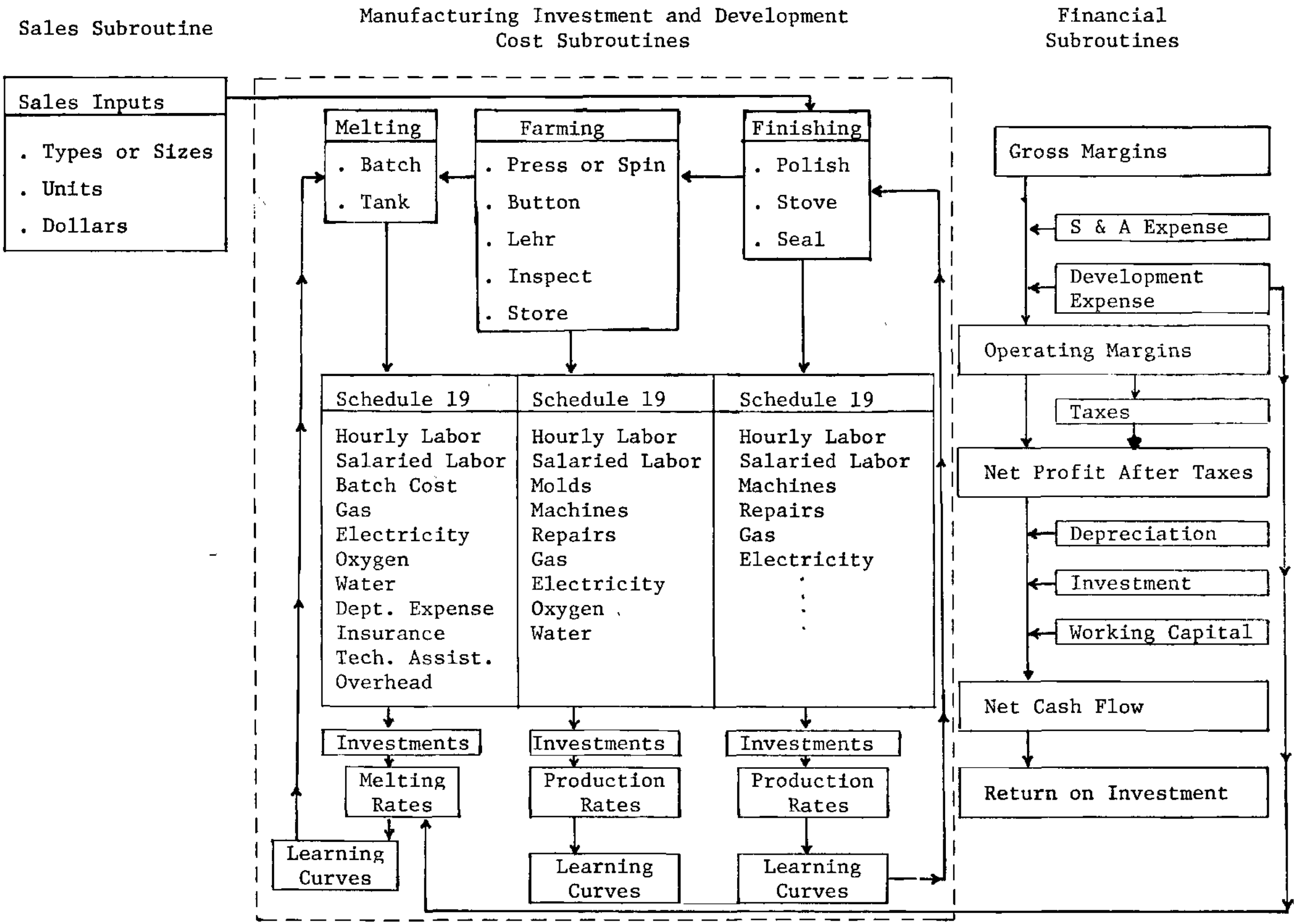


FIGURE 2.20 EXAMPLE OF INPUTS FOR RISK ANALYSIS MODEL

to the plant location model. Given sales levels determined by the market research and marketing model, the production model generates probability estimates vis-a-vis the ability of the company to meet commitments of this magnitude. This model "...takes into account the scheduling of R&D as well as production to determine whether a desired amount of time will be available for research and development so that improvements in manufacturing can be made and the desired profits ...realized." As can be seen from the foregoing discussion, the production and capacity planning model can be probabilistic, but can also be run for a set of different estimates.

The authors feel that experience gained by CGW via the use of the abovementioned group of models has provided them with the capability to bring together the various units into a single comprehensive model. Development and use of the smaller models has provided, not only insight into model building in general, but also into the most fruitful means of using this model generated data.

Smith [57] has developed a short-term planning model for manufacturing firms. He explicitly models all major areas contained in the corporate planning function: production, purchasing, personnel, marketing, finance, and working capital. These factors are combined into a comprehensive planning model with the following general form:

maximize: Net contributions of the decision variables to the profit of the Firm (after taxes).

subject to: A set of intra-temporal constraints to define relationships and limitations which arise from the operating status of the firm during the given time periods, and a set of inter-temporal constraints which relate the operating status of the firm in each period to the status in other periods.

The optimization model is linear in constraints, objective function, but does contain some 0-1 variables. These binary variables are needed to allow accurate modeling of "either-or" conditions and "k or m" constraints, to include fixed charges (such as set up costs), and to control the sequence of appearance of variables in the solution where necessary. This latter instance might arise via a piecewise linear approximation of a nonlinear objective function.

A full presentation of the model would exceed the scope of this review. Thus discussion will be limited to the production area of the model.

The contribution to the objective function of and constraints associated with the production activity are given below.

Contribution: $$-\sum_{t=1}^{T} \sum_{p=1}^{P} q_p \, (X_{pt} + X'_{pt})$$

Constraints:

<u>Equipment</u>

$$\sum_{p=1}^{P} \varepsilon_{vp} X_{pt} \leq E_{vt}$$

$$v = 1,2,\ldots,V \qquad t = 1,2,\ldots,T$$

$$\sum_{p=1}^{P} \varepsilon_{vp} X'_{pt} \leq E'_{vt}$$

Labor Supply

$$\sum_{p=1}^{P} \beta_{np} X_{pt} - L_{nt} \leq 0$$

$$n = 1,2,\ldots,N$$
$$t = 1,2,\ldots,T$$

$$\sum_{p=1}^{P} \beta_{np} X'_{pt} - H_{nt} \leq 0$$

Raw Materials

$$\sum_{p=1}^{P} mrp \, (X_{pt} + X'_{pt}) - I^{m}_{rt} - M_{rt} - M'_{rt} \leq 0$$

$$r = 1,2,\ldots,R$$
$$t = 1,2,\ldots,T$$

where

X_{pt} = number of units of product p produced during regular in period t

X'_{pt} = number of units of product p produced during overtime in period t

q_p = variable production cost per unit of p excluding labor and raw materials costs

E_{vt} is the number of hours of equipment v available for regular time production in period t

E'_{vt} is the number of hours of equipment v available for overtime production in period t

ε_{vp} is the number of hours of equipment v required in the production of each unit of product p

L_{nt} is the number of hours of labor of type n hired during regular time for production in period t

H_{nt} is the number of hours of labor of type n hired during overtime for production in period t

β_{np} is the number of hours of labor type n required in the production of each unit of product p

I^m_{rt} is the number of units of raw material type r available at the beginning of period t

M_{rt} is the number of units of raw material type r which are to arrive in period t and are to be paid for promptly

M'_{rt} is the number of units of raw material type r which are to arrive in period t and are to be paid for at a later date

m_{rp} is the number of units of raw material type r which is required in the production of each unit of product p

Subscripts p = 1,2,...,P do not necessarily imply an individual product, but rather an aggregation of several products with virtually homogeneous production requirements. This allows for a decrease in the number of variables which must be treated.

Smith notes that the model as presented in equation form is not suitable for application to any specific company:

> The following discussion and formulation of the short term planning model only provide the basic structure and general guidelines for modeling the short term planning problem for a specific firm. In the presentation of the model, the definition of variables, parameters, objective function, and constraints is intended to enable an organized adaptation of the model to fit a specific operation, and to suggest the information required for its use.

In the application of the model, Smith estimated that a cost of 2 and 1/2 man months or roughly \$3000 - \$7000 was needed to render the model usable. Solution of the model was via a large-scale nonlinear programming code with total computing costs falling in the range from \$600 - \$1200.

2.7 Synthesis

An expanded characterization scheme is used to compare the models cited in this section. These models were examined with respect to the following attributes:

Optimization: linear or nonlinear

Simulation

Case Study

Stochastic

Planning Language

Small Business

Manufacturing

Online

General Applicability

This comparison is illustrated in Table 2.5. The assignment of an attribute to a given model implies that, at least in part, the model manifests this characteristic. Thus, a simulation model which optimizes in a particular component is classified as both a simulation and optimization model The models described here, as a group, display those characteristics which proved to be most common in the studies cited above. There is a clear predominance of case study simulation models with no stochastic variables. Most are either fully constructed models of a particular company, or planning languages which require that actual model construction be performed by the user. Moreover, the majority do not treat the productive processes of the firm, except implicitly via the assignment of costs in an accounting framework.

The Manufacturing Venture Planning Model (MVPM) which is presented here has the following characteristics:

1) A deterministic, case study, simulation modeling approach.
2) An orientation toward the new manufacturing venture.
3) Online, interactive capabilities.
4) General design to allow treatment of different venture configurations.
5) Explicit treatment of productive processes and associated nonfinancial resources.

These attributes of the MVPM are illustrated in Table 2.5.

Table 2.5. Summary of Model Characteristics

Group	Model	Optimizing: linear	Optimizing: nonlinear	Simulation	Case Study	Stochastic	Planning Language	Small Business	Manufacturing	Online	General
1	CDD	X			X					X	
	Dickens	X			X						
	Hamilton and Moses		X		X				X	X	
2	Gershefski			X	X						
	Stone			X	X					X	X
	Burrill			X	X						
3	PROPHIT II			X	X		X		X[1]	X	X
	PSG II			X	X		X		X[1]		X
	FAPS			X	X		X		X[1]	X	X
4	PPCS			X	X			X		X	X
	SMALBIS			X	X			X		X	X
	Des Jardins and Lee	X		X	X	X		X	X		
5	Baker and Damon	X							X		
	Harrison and Baker	X		X	X				X	X[2]	
	CMS			X		X[3]		X	X		
	Smith		X						X		X[4]
*	MVPM			X	X			X	X	X	X

[1] If modeled by users of the planning language.
[2] Only certain parts of the model are run online.
[3] In certain model segments.
[4] Extensive conversion required for application.

There is a lack of previous work intended specifically to address the planning data analysis problems of the entrepreneur. As the foregoing material documents, another model (other than MVPM) does not exist which at once (1) is oriented towards new venture planning, (2) explicitly treats aspects of manufacturing processes, and (3) is not company specific. The need for a model which possesses these characteristics and the others cited above is discussed in the next chapter.

CHAPTER III

FACTORS UNDERLYING MODEL SPECIFICATION

The foregoing material was intended to provide the reader with a sense of how the model developed here fits into the continuum of modeling work done by others. Surveys of modeling literature and specific models have been examined to provide a frame of reference for further discussion.

In the remaining chapters, the MVPM is explained in greater depth. Having seen how it differs from existing models, we now examine model characteristics as they relate to the needs of the new venture planner. The structure of the model-user interface is discussed leading to a description of important model features in the next chapter.

3.1 Modeling Approach

The approach to developing a computer planning model may proceed in one of two directions: A simulation model, or an optimization model. As discussed earlier, studies of planning practice have shown the optimization models to be relatively rare in actual application[1]. What follows below is a discussion of factors lending to the specification of the model type used here. Additionally, a discussion of venture feasibility analysis provides background for the selection of model input and output (I/O) characteristics which are discussed later.

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[1] See also Naylor and Shauland [46].

3.1.1 Venture Analysis

The process of assessing the economic desirability of an investment project or a new venture is composed of three areas of study and analysis [10]:

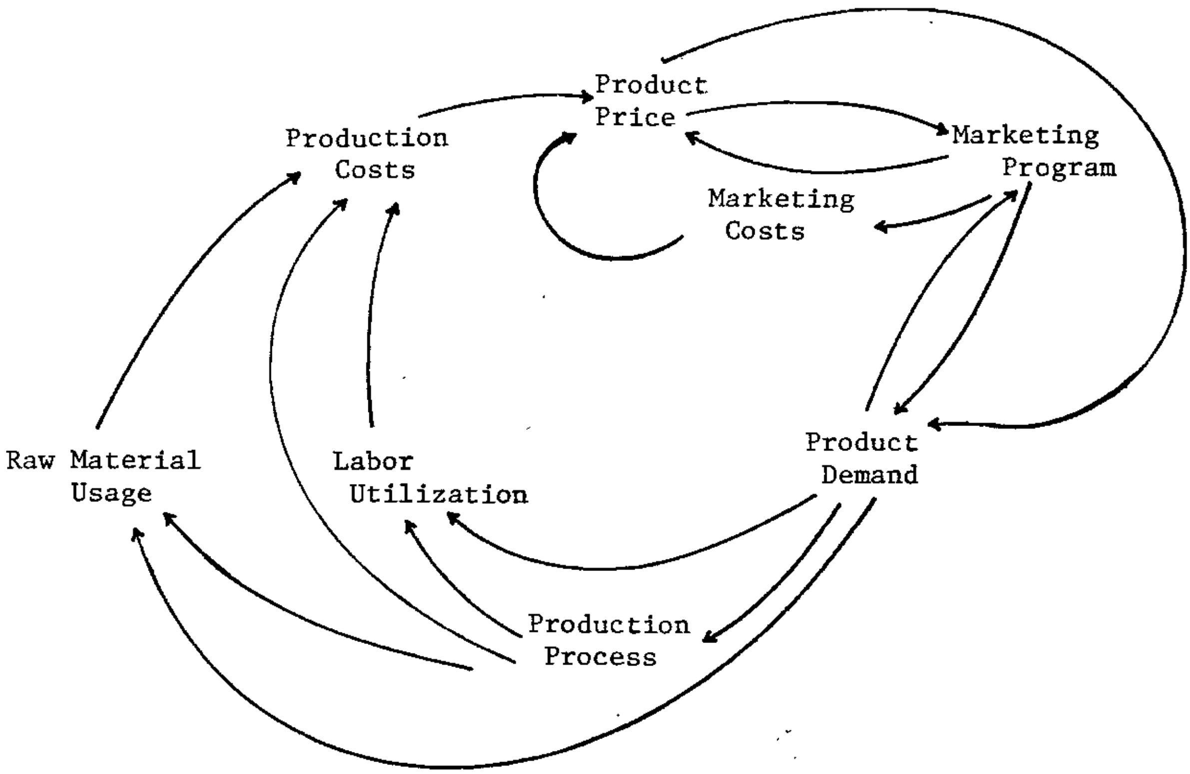
1) Market Analysis to evaluate the venture in terms of present and future product demand, price, market share, and allow planning of sales, advertising, distribution, and customer service efforts and associated costs.
2) Technical Analysis to establish technical feasibility and provide a basis for cost determination. Description of alternative designs for product, process, and scale of plant must be evaluated to select the best combination. Estimation of start-up costs, labor requirements, materials costs, energy alternatives, equipment configurations and costs, and plant overhead are among the principal results of this analysis.
3) Financial Analysis to prepare financial statements so that the venture may be evaluated in terms of measures of financial profitability, and so that the amount and timing of financial requirements may be determined. Components of this study are various pro forma statements -- cash flows, income statements, and balance sheets -- and supporting documents stating assumptions underlying statement preparation. Ultimately, evaluation of economic feasibility rests upon an analysis of this information. This evaluation process includes use of various measures of return and profitability, other key financial ratios, break-even analysis, and the analysis of

the sensitivity of these indices to changes in parameter estimates.

From the description of the component parts of the economic feasibility study, it is clear that the market and technical analyses provide the input to the financial analysis. Not as apparent, but of great importance to one engaged in such a study, are the complex interdependencies and feedback relationships present among all components. These are particularly important in relation to the marketing and technical analyses. This characteristic of the planning process is summarized by the following statement by Hammond [27]: "One danger, however, of presenting the process as a sequence of steps is that such presentation masks its iterative nature. The (analyst) should keep in mind that much looping back occurs when inadequacies or inconsistencies stemming from earlier steps are uncovered in a later step."

A simple example of such interaction is illustrated in the causal diagram which follows at the top of page 84 (arrows indicate direction of causality).

Product price, marketing program and costs, and product demand would be specified as a result of the market analysis, with the other four variables being part of the technical analysis and developed based on the results of the market study. However, the value of the product price variable must initially be given based on some combination of intuition and relevant industry data. It cannot stem from consideration of production costs, since these costs are not yet developed. If, upon their development, an infeasibility is identified (such as lack of solvency in projected operations) then a re-evaluation of all components



of the marketing plan is necessary. This subsequent re-examination of alternative technical configurations and costs, as well as the potential for further infeasibilities illustrates the necessarily iterative nature of the process of feasibility analysis.

The determination of a satisfactory venture configuration may be achieved by examination of the marketing and technical areas, sequentially or simultaneously, and use of the resultant data as input to the financial computations. As mentioned above, this requires providing initial values for some variables. Work done in some phase of one analysis may indicate needed changes in work done previously in that, or some other area of investigation. By modification of initial values, where necessary, alternative feasible configurations may be created. Further modification and recalculation continues until an acceptable outcome is produced, or the decision is made not to proceed with the project.

It can be seen that the decision process inherent in the procedure described above would be enhanced to the degree that the information available for evaluation was complete and accurate. It would therefore be desirable for a complete analysis to be performed for several attractive venture configurations.

The decision among these clearly articulated and explored alternatives would hinge not only on their calculated economic characteristics, but also on an evaluation, objective or subjective, of their respective risk characteristics. To this end, the modification of base case[1] assumptions on revenues, costs, and other factors, and the analysis of the outcomes of these different scenarios, would be very helpful in assessing the riskiness of different alternatives.

3.2 Implications for Model Design

The difficulty with implementation of this concept of evaluating the results of analyses of disparate sets of information is the amount of computation involved. It requires a substantial investment of human resources if computation is performed manually: the "...volume of computation is enormous, and the number of permutations which can be tried

[1]The "base case" (as defined by Kingston [32]) is a user-accepted set of input data, projections, and documentation. After the base case is accepted, it is used as a reference point for evaluation of the results of "what if" questions.

out must be severely limited unless the experimenter has access to the computational power of a computer [44]." The calculations required are generally not complex, but are tedious and time consuming; so much so that for a lone entrepreneur or small group engaged in analysis, the sheer magnitude of the task precludes much potentially fruitful exploration.

Of benefit in the amelioration of this difficulty would be some tool to relieve the analyst of the burden of much of this computation, thus allowing him to concentrate on use of his most valuable attribute - judgmental ability. Once the generation of alternative solutions no longer requires prohibitive commitments of time and manpower, the analyst will be prone to generate and analyze more information, thus improving the basis for the entire planning process.

It may be concluded from the foregoing discussion that an important capability in the performance of a feasibility analysis is the ability to evaluate alternative venture configurations. Though only one explicit method for doing this has been considered, it should also be noted that this process may also be implicitly performed via the use of an optimization model. However, the use of some mathematical programming procedure for the determination of an "optimal" configuration is contraindicated for two reasons.

The first reason is that the lack of historical data regarding the proposed new venture forces the model-generated plan, "optimal" or otherwise, to arise from data which is suspect. Thus faith in a plan's optimality would likely be misplaced. Indeed, in discussing corporate models, Grinyer and Batt [26] note that:

> ...due allowance should be made for the inaccurate and often subjective nature of projections and forecasts, of both costs and revenues, used as input to models. This in turn suggests that any model developed would be used in an exploratory, simulation fashion. Also, it may be argued that highly sophisticated and expensive approaches should not be used in such circumstances.

Bearing in mind that Grinyer and Batt were discussing corporate modeling in relation to going concerns, one can readily imagine the "inaccurate and subjective nature" of inputs generated totally without the benefit of past operating data. Thus the focus should be upon the range and sensitivity of outcomes, rather than upon theoretical optimums.

The second, but perhaps more crucial objection to an optimization approach is the consideration of the human factor in the process of analysis. Of prime importance in a manager's (or entrepreneur's) acceptance of a machine-computed solution is his ability to understand the method by which the solution was reached. The following statement by Lorange and Rockart [38] addresses this aspect of the planner-model interface.

> No line manager is going to work with an abstraction or compaction of reality that is different from his own. As a result, he must understand the model that he is using... An outside model, to be accepted therefore, must treat a very simple part of the planning process--such as the extension of pro forma profit and loss statements and balance sheets.

This straightforward generation of financial data, when accompanied by consideration of important nonfinancial areas (such as materials and staffing requirements), comprises the most time consuming part of the manual assessment of feasibility. The performance of the requisite computations, and the facility for user interaction and evaluation of multiple parameter combinations is the task for which the model described hereinbelow has been developed.

3.3 Intended User Characteristics

Persons working with the model may be generally classified into two groups. These groups correspond to the two types of activities associated with the model: model maintenance and support, and business planning.

3.3.1 Maintenance Level

In an operational setting, use of the model would require, among other things:

1) Access to a computing system.
2) Modification of model and/or documentation, if necessary, to facilitate compatability with the system being used.
3) Placement of model into appropriate storage medium.
4) Changes in model and/or documentation as indicated by experience with usage.

The usefulness of any piece of software which purports to be of general applicability is severely hampered by heavy use of programming features idiosyncratic to a particular computing system. Transportability is a desirable attribute in this situation, to allow for use where needed, regardless of the hardware available. The transportability of the model is enhanced by the effort to use, to the degree possible, only general language characteristics. For the modeling effort under discussion, this means the use of standard FORTRAN IV[1], except where

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[1]It should be noted here that FORTRAN IV is the most common language for computerized corporate models [22,26].

compatability with the (CDC Cyber 74) system mandates the use of some special (CDC) convention (e.g., the "PROGRAM" statement).

Due to the differences between the implementation of FORTRAN IV on various systems, it is very probable that some modification of the model discussed here will be necessary. This is unavoidable. The benefit of coding with transportability in mind is that the number of such modifications will be minimized[1].

Experience with model usage may indicate desirable changes in assumptions or structure. Such changes might become indicated, not because of the specialized needs of one particular user, but because of environmental changes: practices characteristic of one region of the country, tax law changes, etc. These modifications all relate to making the model available for end use in assisting in new venture planning. The types of skills associated with either of these activities clearly require familiarity with the computer in question, as well as higher level (FORTRAN) programming capability.

The need for personnel with a computing background should not, however, be a problem since constant maintenance is not envisioned: rather, a minimal one-time effort to get the model "up" and running, and the performance of any changes that may, from time to time, be necessary.

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[1]Frendeway, Duea, Monarchi and Taylor [20] make the distinction between "portability" and "transferability." The latter term is defined as the extent to which the concepts employed in a model are applicable to differing situations. Portability implies that the (computing) resources needed for model implementation are widely available. Given the modeling philosophy used and the avoidance of site-specific programming practices, the MVPM satisfies both of these criteria.

3.3.2 User Level

The ultimate model user will be the person (or group) responsible for and most concerned with the success or failure of the venture under consideration. Thus, to be of maximum usefulness, the model must be amenable to use by entrepreneurs and other people involved with new venture planning, management and guidance.

The model is therefore oriented, in its input, output, and general methodology, towards a user with a general management background, but little or no experience with computers. This general management background implies sufficient comfort with normal business reports and concepts to allow understanding of pro forma statements and other documents of similar focus when presented in a standard form. Thus the output of the program is in formats similar to those used in manually generated planning documents, while the input, insofar as possible, does not require knowledge of computer usage (for a discussion of the desirability of this approach to model I/O see Russo [51]). Obviously some basic activities must be learned: gaining access to the system, data input, calling of the program, etc. However, they are of such an elementary nature that their mastery should pose no problem.

In summary, a government agency (such as the SBA) or a financial institution, should be able to maintain the model. End users, with a small amount of training, should have the ability to operate the model unassisted. Given the complexity of the problem with which they are faced, these manager-users should find that the benefits to be gained from model usage far outweigh the cost of time spent in learning to use it.

CHAPTER IV

MODEL OVERVIEW

4.1 Introduction

The manufacturing venture planning model described here has been developed in accordance with the following guidelines:

1) Generalized structure rather than company or industry specific structure.
2) Orientation toward the manufacturing enterprise.
3) Case study simulation approach.
4) Provision of data of specific usefulness in new venture feasibility analysis.
5) Capability for multiple scenario analysis.
6) Formulation to allow for model/user interaction during processing.

Items one through three above have been discussed previously. Item four constitutes the central theme of the model. It implies not only consideration and documentation of the flow of financial resources, but also the treatment of the technical factors which give rise to the costs used in the development of financial information. In the context of a corporate or whole-company model, this requires that a balance be achieved between the generation of relevant information, and the incorporation of excessive detail.

Efforts at modeling in an industrial setting mainly fall into two categories -- operating models and financially oriented corporate planning models [30]. The former are specific models of various isolated aspects of the business. They usually are composed of closed form analytic optimization techniques or detailed simulation of operations[1]. Corporate planning models, on the other hand, typically deals with all company operations as a single entity. They concentrate on the generation of economic information, often at the expense of full treatment of the firm's productive operations.

In the history of approaches to model building, the first attempts at modeling were the construction of various operational models (see Hayes and Nolan [30]). The early emphasis on this type of model was due to several factors including:

1) Previously developed algorithms for problem analysis.
2) Clarity of structure in specific operating units.
3) Ease of observation and availability of quantifiable data.
4) Predictability of important events and straightforwardness of associated decision criteria.

Quite naturally, attempts to construct models on a corporate planning scale were initially agglomerations of operating models of various constituent functional units. Despite the intuitive appeal of this "bottom-up" approach, these early attempts led to the creation of "...incredible Frankenstein Monsters which fortunately died before they could do much harm [30]." The reason for the intractability of this

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[1]An example of the detailed simulation approach is the "Materials System" discussed by DesJardins and Lee [13]. The model of DesJardins and Lee is company specific and bottom-up, as discussed in Chapter two.

approach was that the detail of functional form and data needed for an accurate operational model quickly grew unmanageable as the modeling of different areas was combined.

What is presented here is a generalized framework which is holistic in viewpoint. Detailed consideration of productive processes are incorporated to the degree necessary to:

1) Allow generation of cost flows from technical data.
2) Supply information on flows of nonfinancial resources: manpower, energy, raw materials, and finished goods.
3) Allow for evaluation of the capital investment decision at indicated points in the planning period.

The approach taken in specification of the MVPM may be described as "top-down". This implies a logical progression from the desired result of the modeling effort, through the identification of its component parts, ending with the specification of the data required for model operation.

For purposes of clarity of exposition, this ordering will be disturbed somewhat, with inputs and outputs initially being discussed in that order. Then the black box which links these two bodies of information -- the synthesis of model and user -- will be discussed.

4.2 Scope and Limitations

The venture analysis framework presented earlier will be used for the balance of this chapter, as it provides an excellent framework for the presentation and discussion of the large volume of information that must be considered in the planning process. With this background established, we now turn to a detailed treatment of model data and assumptions. In instances where these may seem overly restrictive, the reader may infer that the restrictions were incorporated into MVPM to allow for straightforwardness of model construction. Suggestions for useful relaxation of assumptions or form of data entry are deferred until Chapter VIII.

The model input quantities (Table 4.1) are expressed so as to conform to traditional business data aggregations. This approach is taken rather than data entry being oriented toward the internal construction of the model. Requesting input in a user-oriented format is discussed by Little [37] who states that "...coefficients and constants without clear operational interpretation are to be discouraged. Let them be inferred by the computer from inputs that are easier for the user to work with."

Two possible exceptions to this overall conformity are the technical inputs numbered eight and nine. These questions of labor policy would normally be a by-product of day-to-day operating management decisions. They must, however, be explicitly defined for the model, to prevent fluctuations of manpower that would negate all efforts at expressing realism in model form and output. This is consistent with Little's concept of "robustness" of model design: the incorporation of safeguards against bizarre results.

These required inputs are complimented by the model assumptions and restrictions shown in Table 4.2. This list of assumptions is not meant to imply complete treatment of all factors not mentioned. Rather, it is an illustration of those factors modeled in the indicated form.

TABLE 4.1

Model Inputs

Marketing

1. Product demand schedule by month for a five year planning period.
2. Product price.
3. Percentage of accounts receivable that are uncollectable due to returns, allowances, and bad debt.
4. Marketing expense budget by month, including advertising and promotional expenses, salesmen salaries, commissions, travel expenses, etc.

Technical

1. Finished goods production schedule by month.
2. Quantity of each type of material required per unit of production and percentage scrap and reject rates. Also, the smallest available purchase quantity, fixed and variable cost, and order lead time for each type of material.
3. Description of equipment required for each production step, including its purchase cost, expected life, scrap value, expected percentage downtime, maximum production rate, and equipment order and setup lead time.
4. Labor requirements for each equipment configuration, including skill level(s) required and expected productivity in relation to use of this equipment.

TABLE 4.1 (cont'd)

5. Labor wage rates, and costs of hiring and firing as a percentage of regular time monthly wages.
6. Wage rate for overtime work and the maximum amount of overtime work allowed per employee per day.
7. The maximum number of work shifts per day.
8. A level of overtime which is acceptable on a semi-permanent basis and the maximum number of months that this level may be exceeded.
9. Minimum workforce contraction period: the shortest time between hiring and firing of an employee.
10. Building square footage requirements and monthly rental cost per square foot.
11. Factory overhead, including supplies, indirect labor, maintenance and repair, insurance, and other items not explicitly included elsewhere. Overhead is expressed as a function of scheduled monthly production hours.
12. Energy/Utility types and costs.

Administrative

1. Budget of wages and salaries of administrative personnel not included under marketing expense or factory overhead.
2. Office equipment purchases budget.
3. A budget of other administrative expenses by month, including office rental and supplies, office equipment rentals and repairs, administrative communication and travel expenses,

TABLE 4.1 (cont'd)

insurance premiums, fees for professional serivces, etc.

Financial

1. Equity capital invested.
2. Interest rate for borrowed funds.
3. Payroll taxes and fringe benefits as a percentage of payroll.
4. Ad valorem tax rates on inventories and equipment, and minimum equipment value for tax purposes (% of depreciable cost).
5. Income tax and surtax rate and break point.
6. Minimum cash balance as a percentage of monthly cash outflow and outstanding debt.
7. Start-up loan amount.
8. Minimum attractive rate of return (annual effective discount rate) to be used in discounted cash flow calculations.

TABLE 4.2

Model Assumptions and Restrictions

Marketing

1. Sales are for cash payable within 30 days. Therefore payments are received at the start of the month following the sales transaction.
2. Shipment costs are paid by the customer and do not enter the analysis.
3. If in any given month, orders are greater than the quantity of product available for sale, the excess sales are lost rather than backordered.

Technical

1. The enterprise operates in rented facilities.
2. All purchases of materials, supplies, equipment, etc. are for cash payable within 30 days.
3. The costs of shipment (and installation if necessary) of all materials, supplies, and equipment are included in the cost inputs for those items.
4. No interruption in the availability of materials, supplies, equipment, utilities, etc.
5. Learning time for new workers to reach full productivity is negligible. This potential complexity can be incorporated via appropriate selection of the cost of hiring.
6. Orders for raw materials and equipment are placed and received on a beginning-of-month basis.

TABLE 4.2 (cont'd)

7. Only full time employment is used.
8. The size and skill class composition of required staffing for a given piece of equipment is invariable.

Administrative/Financial

1. Wages and salaries are paid at the end of each month.
2. The enterprise is treated as a corporation for accounting and tax purposes.
3. Income taxes are paid quarterly, within 30 days after the end of the quarter.
4. Funds can be borrowed or repaid monthly. Funds cannot be borrowed for periods less than one month.
5. Inflation is not handled within the model.
6. Equity investment occurs only once; in the start-up period.
7. All depreciation is via the straight line method.
8. All equipment used has expected useful life of at least five years.
9. All office equipment has an expected useful life of exactly five years.
10. No dividends are paid during the planning period.
11. Borrowing is done at the beginning of the month, and interest is due on any outstanding debt at the end of the month.
12. Repayment of principal will be made when the cash balance exceeds the greater of the minimum desired cash balance and the required compensating balance.

TABLE 4.2 (cont'd)

13. Any asset disposal during the planning period is at book value.
14. Ad valorem tax is assessed at year end and is due at the end of the following quarter.
15. Purchases during the start-up period are payable during the first month of operation.
16. Interest on loan amounts accrued during start-up period are negligible (or indeterminate).
17. Equipment sales transactions take place in the same month that replacement equipment becomes ready for use.

The assumptions stated would most likely not characterize the environment or operations of any particular going concern. But, insofar as they might apply to a "typical" manufacturing firm, it is felt that they are suitable for use in the analysis of a broad range of new business ventures.

The model output, which is listed in Table 4.3, is composed of those documents needed for venture feasibility analysis, augmented by information needed for planning of operations. The length of the planning period chosen (five years) casts the model in the role of an "intermediate range" planning tool [9]. The selection of this period was admittedly arbitrary. It was chosen primarily in consideration of the informational needs which are a part of the process of acquiring external funding (either debt or equity); such as, an entrepreneur presenting a business plan for consideration by a commercial bank. Five years appears to be a reasonable planning horizon, particularly in view of the substantial uncertainty associated with the data underlying the new venture planning effort.

An important trade-off between realism of planning results and creativity in planning -- corresponding respectively to very short and very long planning periods -- is involved in the selection of a planning horizon.

> Nowhere in the whole range of system-design features is the trade-off between realism and reach more clearly defined than in the choice of a planning horizon. The longer the time frame, the wider the range of factors which can be varied and thus the broader the range of strategies which can be considered...
>
> At the same time, a longer time span increases the uncertainty regarding environmental assumptions, corporate strengths, and the financial parameters which shape the strategy formulation and

TABLE 4.3

Model Outputs

Marketing (monthly with annual summaries)

1. Sales (units and revenue).
2. Lost sales (units and revenue).

Technical (monthly with annual summaries)

1. Units produced.
2. Finished goods inventory (end of period).
3. Employment by skill level (end of period).
4. Overtime hours worked by skill level.
5. Equipment additions by type.
6. Surplus process capacity.
7. Energy/utility use in production activity.

Financial

1. Pro forma cash flow analysis (monthly with annual summaries).
2. Pro forma income statements (quarterly with annual summaries).
3. Financial ratios of profitability, liquidity, etc. (annual).
4. Discounted cash flow calculation of net present value for the enterprise, and the sensitivity of this index to variations within a preset range around the specified discount rate (at end of run).
5. Graphical display of monthly cash flows (at end of run).

> evolution process. At some point, uncertainty overcomes the gain in flexibility [55].

Clearly, the uncertainty mentioned in the above quote is compounded in the case of a new venture. A five year horizon seems to allow a reasonable balance between the stimulation of forward thinking on the part of the planner [55], and the avoidance of overconfidence in planning data.

There are two forms of financial reporting which are conspicuous by their absence: balance sheet information and break-even analysis. A balance sheet is not produced by the model, at present, largely because of the seminal nature of the current work. The necessary aggregation and manipulation of data and report generations required to yield quarterly and annual balance sheets is an obviously desirable extention of the model.

The model presently collects enough information to create break-even information, given typical assumptions about the sources of significant variable costs. For an established business in a stable environment, accounting entities such as labor expense may be regarded as locally "fixed", with materials expense constituting the major component of variable cost. When we examine the instability with which the new venture operating environment is imbued, the vacuousness of such assumptions is apparent. Thus, in order to meaningfully estimate break-even (unit or dollar) volume of sales, more detailed modeling of costs must be effected.

It should be noted that the user who wishes break-even information has access to it in the current model; albeit in an approximate sense.

One may observe by inspection of the quarterly income statements, the quarter in which the firm does, in fact, break-even: with the level of sales at that point approximating break-even sales.

It should be noted here that the output described above does not necessarily constitute the result of every run of the model, but rather is illustrative of the range of information that is available. Interaction with the model on the part of the user will dictate what subset of this information is produced in any given run.

The remaining set of bounds on model scope are restrictions on the problem size that it can handle. Such restrictions cannot be meaningful presented at this point, since they are best expressed in terms which have not as yet been defined. This discussion will therefore be postponed until section 5.2.1.

4.3 Model-User Interaction

As will be discussed later, the model is of the case study or "what if" variety. This implies that problem resolution will not be achieved through some internal optimization procedure, but rather through repeated runs with differing data.

In this context, it is widely felt that a model with interactive capabilities is needed[1]. Through direct interaction the user can:

> ...put a large number of major or minor questions and receive back the answer within minutes. This allows the (user) to explore the outcome of a variety of options in a short period of time. It also provides a useful medium for learning the structure and implications of the model [44].

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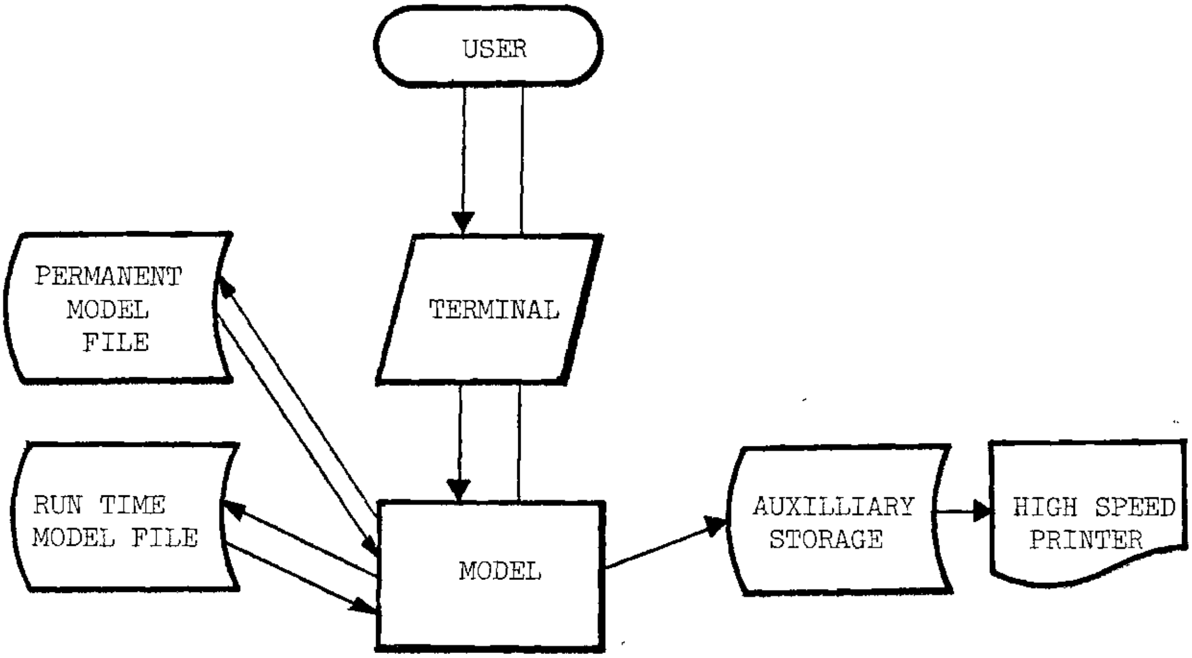
[1]See, for example, McRae [44], Fuehrer [21], Stone et al. [61] and Hammond [27].

In addition, input of certain data from the computer terminal facilitates (data) error checking and correction. For these reasons the model will utilize interactive processing. The flows and collections of data used are illustrated below.



Once the user is in program control, a question and answer command environment is entered. The model solicits user guidance using questions which most often require a response of "yes" or "no". Instructions or data are entered as indicated, with error checking of key data items performed immediately.

Initial entry of a given venture configuration results in this data collection being written to disk in such a fashion that it may be reloaded in subsequent runs as the "permanent model file". If, during the course of a run, the user wishes to save a particular modification of the base case data, this is accomplished via the use of the "run-time model file". Thus, a base case scenario may be stored in the run-time file and reloaded (back into central memory) after a range of alternatives have been examined.

The capability for evaluation of multiple scenarios is enhanced by two additional model features. One is the option to store large amounts of output in a temporary disk file, sending the information to a high speed printing device at the end of model use. The second is the ability to modify only those data for which the user wishes to see the results of changes.

Thus, in a typical application, the user is able to:

1) Get on-line and call MVPM with a previously created permanent data file.
2) Store this configuration, modified as desired, as the base case model for this run.
3) Vary selected data, perform simulation, and direct requested output to the temporary output file.
4) Reload the run-time base model and repeat Step 3.
5) End the terminal session with all output printed on a remote high speed printer[1].

---

[1]Any computer installation with sufficient size to run the MVPM program would have such devices which are also variously referred to as "off-line" or "on-site" printers.

The user may, of course, request that report display take place at the terminal. For this reason, annual "summaries" and plotted output are available, in lieu of (or in addition to) monthly "profiles" to reduce printing time.

Further discussion and examples of user/model dialogue are contained in Chapter VI.

CHAPTER V

MODEL STRUCTURE

5.1 Conceptual Structure

The MVPM may be conceptualized as the union of three subsystems: The Materials and Production Subsystem, the Financial Subsystems, and the Decision Subsystem. These model components, their mutual interactions and use of input data are shown in Figure 5.1. A Model Control System (not shown) handles the flow of information between the subsystems, the initiation of their various activities, and the control of certain data manipulation tasks. Model output is controlled via a Report Generator (also not shown) which retrives appropriate data items, aggregates and modifies where necessary, and creates the desired outputs.

The structure outlined above is a clear and convenient manner of delineating the various activities which constitute model operation. In practice (i.e., as programmed), the distinction between activities in different "subsystems" is often not so clearly defined. Thus for example, a program unit properly subsumed in the M & P subsystem may also compute dollar flows as a by-product of its primary function. Despite this minor conflict, the subsystem definitions outlined above facilitate perspicuousness of presentation, and, in fact, served as the framework for model construction[1].

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[1]It is apparent that this same problem exists in model descriptions by other authors. A review of the DesJardins and Lee [13] and Corning Glassworks [6] models is illustrative of this point. The more detailed the description becomes, the more difficult it is to adhere to a specified classification scheme.

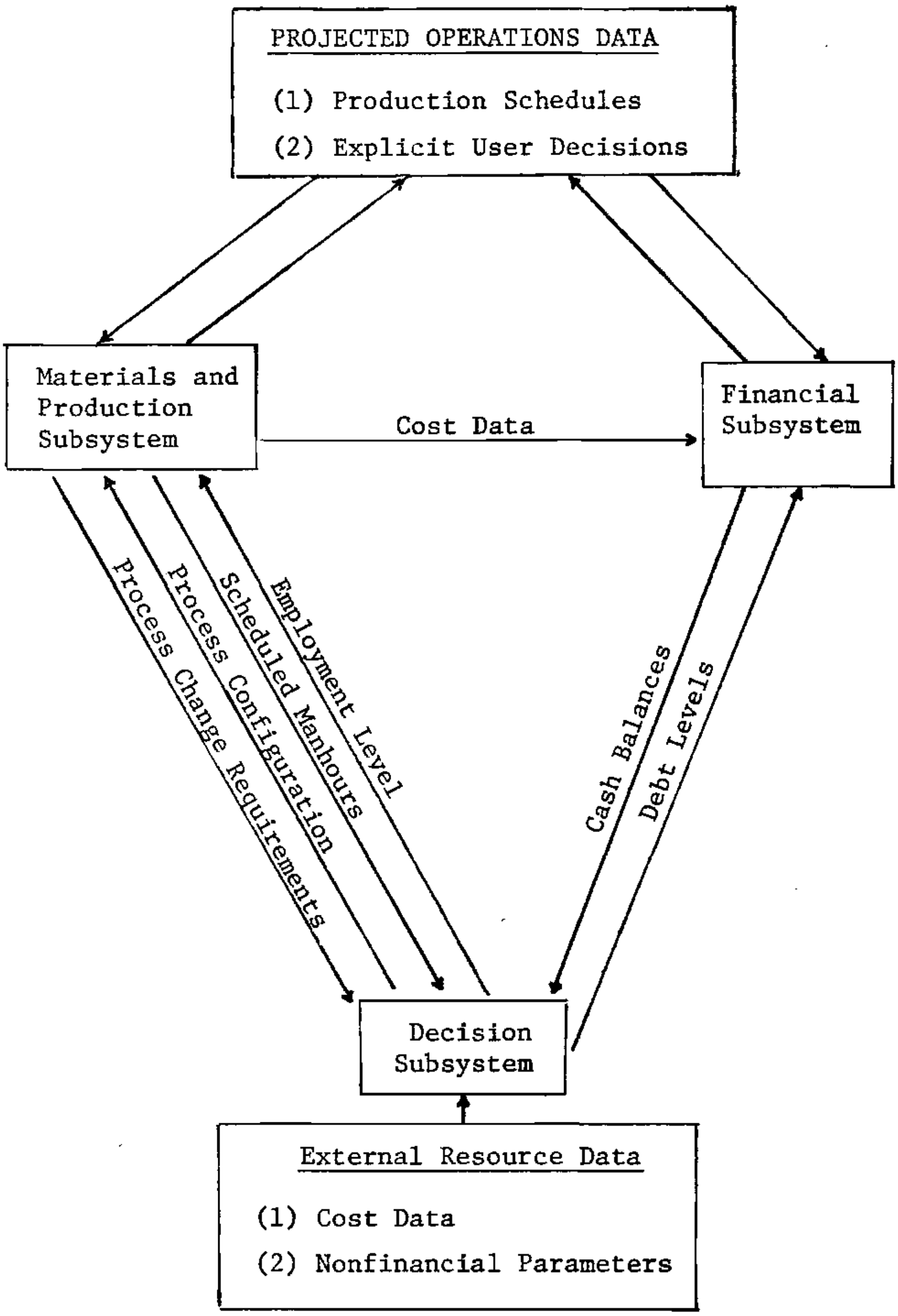

FIGURE 5.1

CONCEPTUAL STRUCTURE

The methodology employed in this translation of production plans into pro forma operations and financial performance is outlined in Figure 5.2. A materials requirements planning or "roll-back" approach is used to relate finished goods production to requisite production of intermediate parts and purchases of raw materials[1]. Data on process step capacity and staffing requirements are used to determine overall employment levels, shift assignments, and capital expansion activity. Cost and revenue data is then collected and appropriate accounting relationships used to generate data items needed for financial reporting.

5.2 Data Definition and Organization

The data used by the model (both input data and computed quantities) is organized internally, not in terms of the functional areas of feasibility analysis, but in terms of the operating environment of the firm. The two classifications used are: Projected Operations Data, and Operating Resource Data. This reclassification is useful since it serves to highlight the different data requirements of the model components: both the components of the conceptual structure and the program units used in the computer implementation of the MVPM.

The general applicability of the model hinges on the approach used in characterizing the manufacturing activities of the firm under study (Figure 5.3). This characterization is achieved by the use of

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[1]As used here, "raw materials" actually refer to any purchased input to the firms productive process. This redefinition greatly enhances the flexibility of the model, as will be seen in Chapter VI.

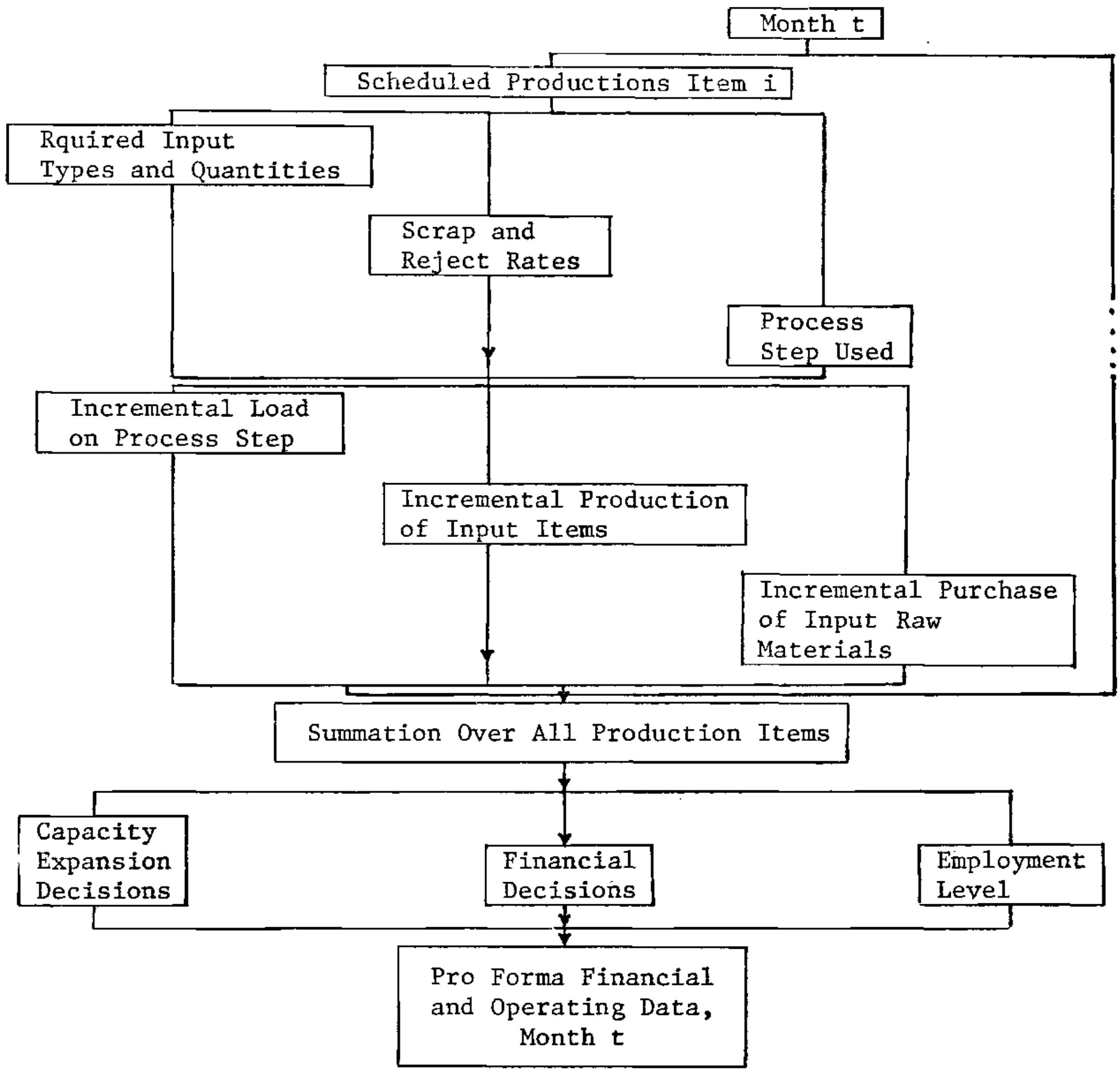

FIGURE 5.2

ROLL-BACK PROCESS

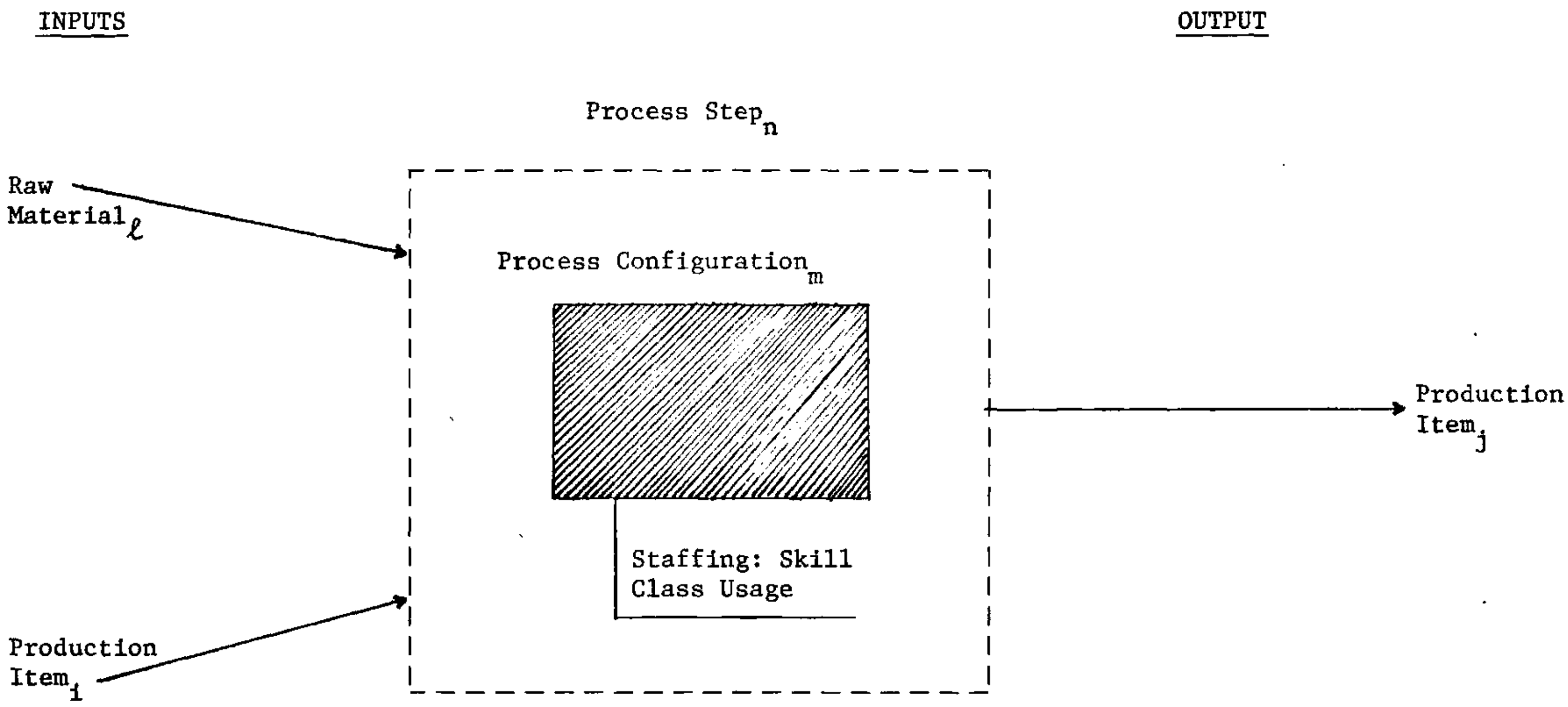

FIGURE 5.3 MVPM: CHARACTERIZATION OF PRODUCTIVE PROCESSES

"process steps" (PS) which are generalized "black boxes" that may be used to represent any part of any operation. A process step contains a "process configuration" (PC) which is a particular equipment type used to perform the task associated with the PS. Capacity expansion is thus effected by changing the PC associated with a particular process step. Personnel are stratified by skill class: each PC has a fixed number of personnel of designated skill classes which it requires for operation. The process step used and component parts for each finished good are entered by the user. This, together with data on each PC completes the bulk of the information needed to schematically represent the manufacturing operations of a firm.

Figure 5.4 shows the data associated with a process step. The identifiers of alternative process configurations which can perform the tasks of this step are listed. This information is used when the decision is made to expand capacity and at the start of simulation, when the first "base case" PC is put into service. The operating data includes the PC used in this step for each month of the planning period (based on production requirements), and the hours down and utilized (up) during each month.

Surplus capacity arises from the assumption that a full eight hour day, 40 hour week is the minimum amount of time that a shift can work. Given this assumption of full time employment, and the assumption that the size and composition of a shift on a given PC is fixed, the number of employees (and hence the number of regular time hours) is determined by the number of process steps and the process configurations which they contain in any given month. Thus, the only quantities that

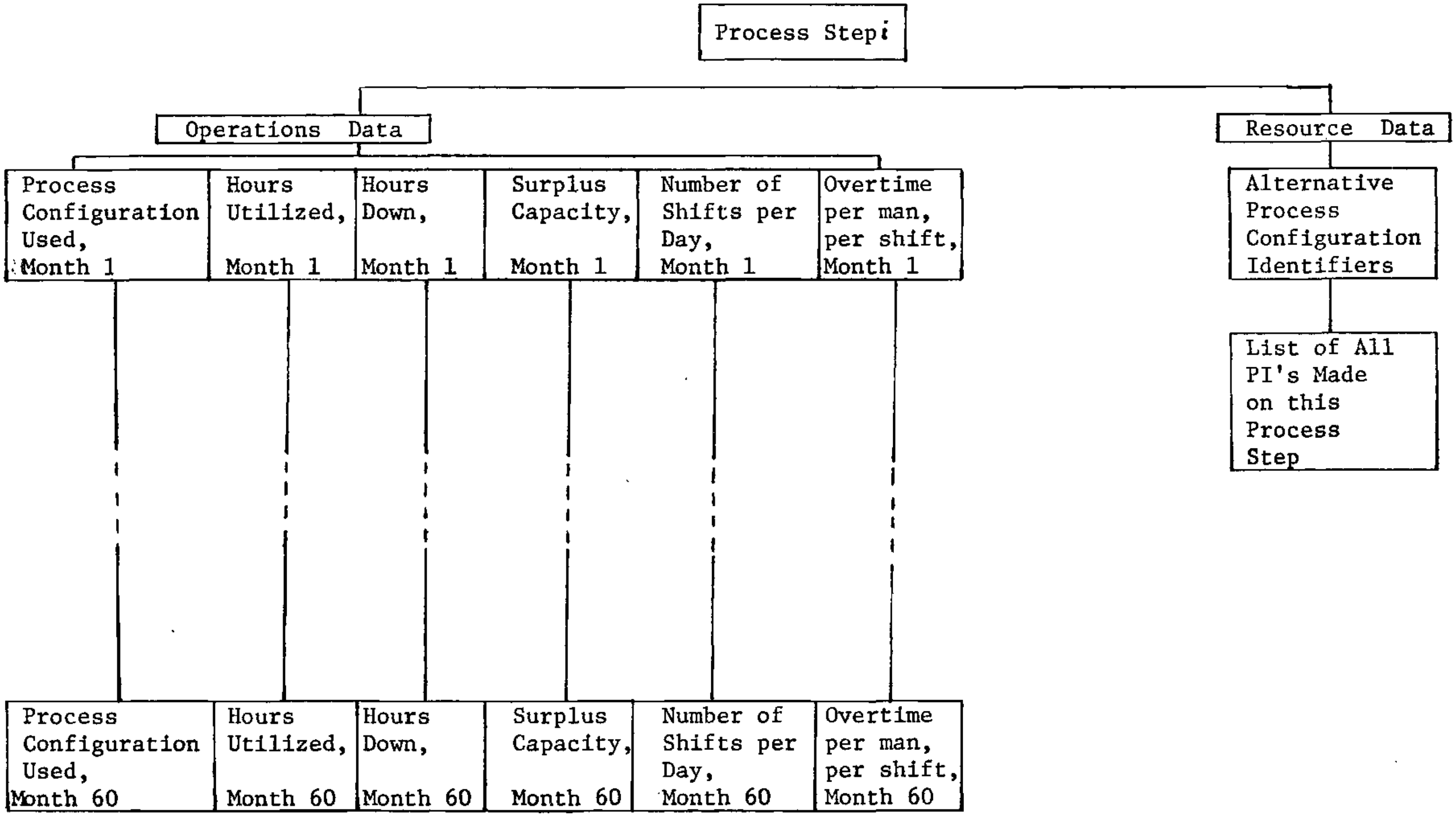

FIGURE 5.4 PROCESS STEP DATA

are not invariable in a specific arrangement of the above factors are the number of shifts per day, and the number of overtime hours per shift month. Storage of these last two quantities in addition to the PS/PC correspondence record, obviates the retention of any further monthly personnel data: all labor operating and financial flows can be calculated in a straightforward manner from these three data types.

Process configuration data is all of the resource variety as shown in Figure 5.5. The configuration ID is used by the model for location of information associated with this PC. The "descriptive information" is included solely for documentation purposes to aid the user in interaction with the model. The order and setup lead times are included to allow indication of appropriate purchase times, and for accounting purposes. Investment requirements are included for the same reason. This figure must include not only the purchase cost of the equipment, but also the costs of all activities required to make it ready for service: e.g., shipping costs, setup costs, facility modifications, initial testing, calibration, etc. Similarly, floor space requirements must be composed of space for placement of equipment and room needed for human activity and movement of materials required for production.

The composition and amount of staffing required for each PC is considered to be fixed. Modification of capacity may not be achieved by decreases in the number of operators in a shift. The difficulty factor associated with the PC allows for particular problems associated with equipment operation: over and above the intrinsic level of productivity associated with a particular skill class of employee.

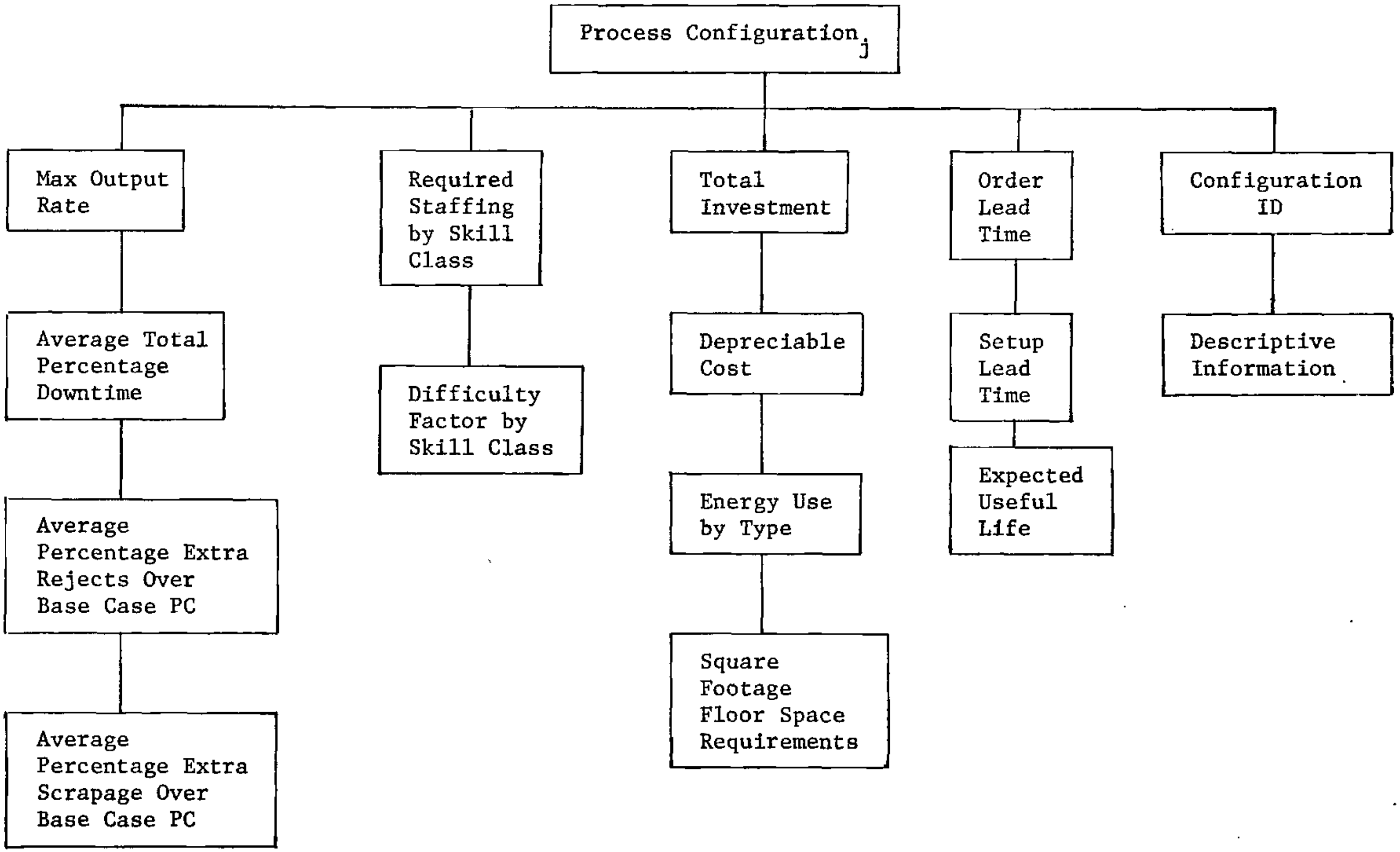

FIGURE 5.5 PROCESS CONFIGURATION DATA

Energy sources and associated average variable costs are input separately as part of model resource data, and each PC description includes the kind(s) of energy used and the amount consumed per unit output.

The last four items of resource data needed to describe the PC concern some of its important operating characteristics. The value for average total downtime included an aggregate figure composed of average values for the percentage of run time that the equipment is down for both scheduled and unscheduled maintenance. Extra amounts of scrap and rejects are defined relative to the base case process configuration used in the corresponding process step. Thus these extra percentages for the base case configuration would be zero, and percentage for other PC's would reflect the (positive or negative) difference in material loss due to their use.

The maximum output rate must be established in relation to normal production volume for some "typical" product. As will be mentioned later, added mechanical difficulty associated with production of a particular item is dealt with via a factor which is part of each item's resource data.

Both finished goods and intermediate parts are considered to be "production items" (PI's). The PI data aggregation, shown in Figure 5.6 consists of both resource and operations data. The former is used to describe the PI's production and the required inputs. The process step in which the item is produced is identified, along with a mechanical difficulty factor associated with production of <u>this</u> PI. The use of this factor provides the flexibility to model situations where different

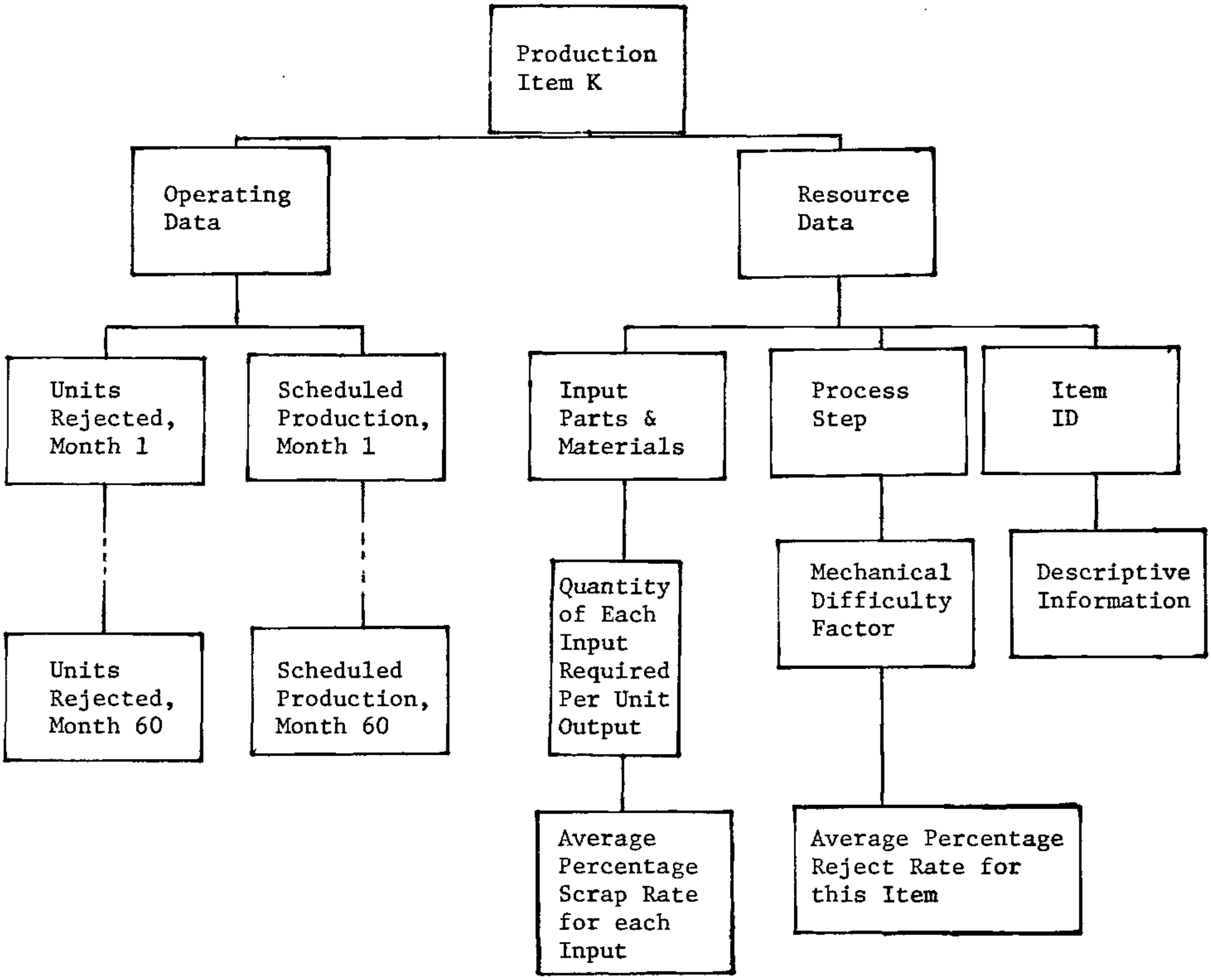

FIGURE 5.6 PRODUCTION ITEM DATA

products are run in an alternating fashion at different speeds on the same machine. For this reason, scrap and reject rates are also associated with PI's rather than with process configurations. These two rates of material loss are not aggregated into a single "loss" index, because this would imply that scrappage occurs in a proportion identical to that in which parts or raw materials are combined to produce a given PI. The rates supplied as inputs for a given PI are those which would be experienced in production of this item on the base case PC selected for the process step which produces this item. The "extra percentages" or weighting factors which are part of the PC resource data allow proper accounting for material loss given capacity expansion in a given process step. In this way, MVPM models the combined effect of process and produced item on loss characteristics.

The quantity required of each input is increased to account for the designated scrap rate, and used to contribute to the production requirements for the input. Similarly, production of the PI in question is increased to allow for the specified percentage of rejects. The actual production and the number of rejected units are stored as part of the model's operations data.

As Figure 5.7 shows, the user enters the amount of each finished good which he wants produced in each month. The modeling philosophy used here is entirely compatable with the treatment of intermediate production items whose production is determined via the roll-back process. Actual production equals or exceeds user-specified production, and is at a level such that the net saleable amount (i.e., total production less reject amount) is equal to production desired by the

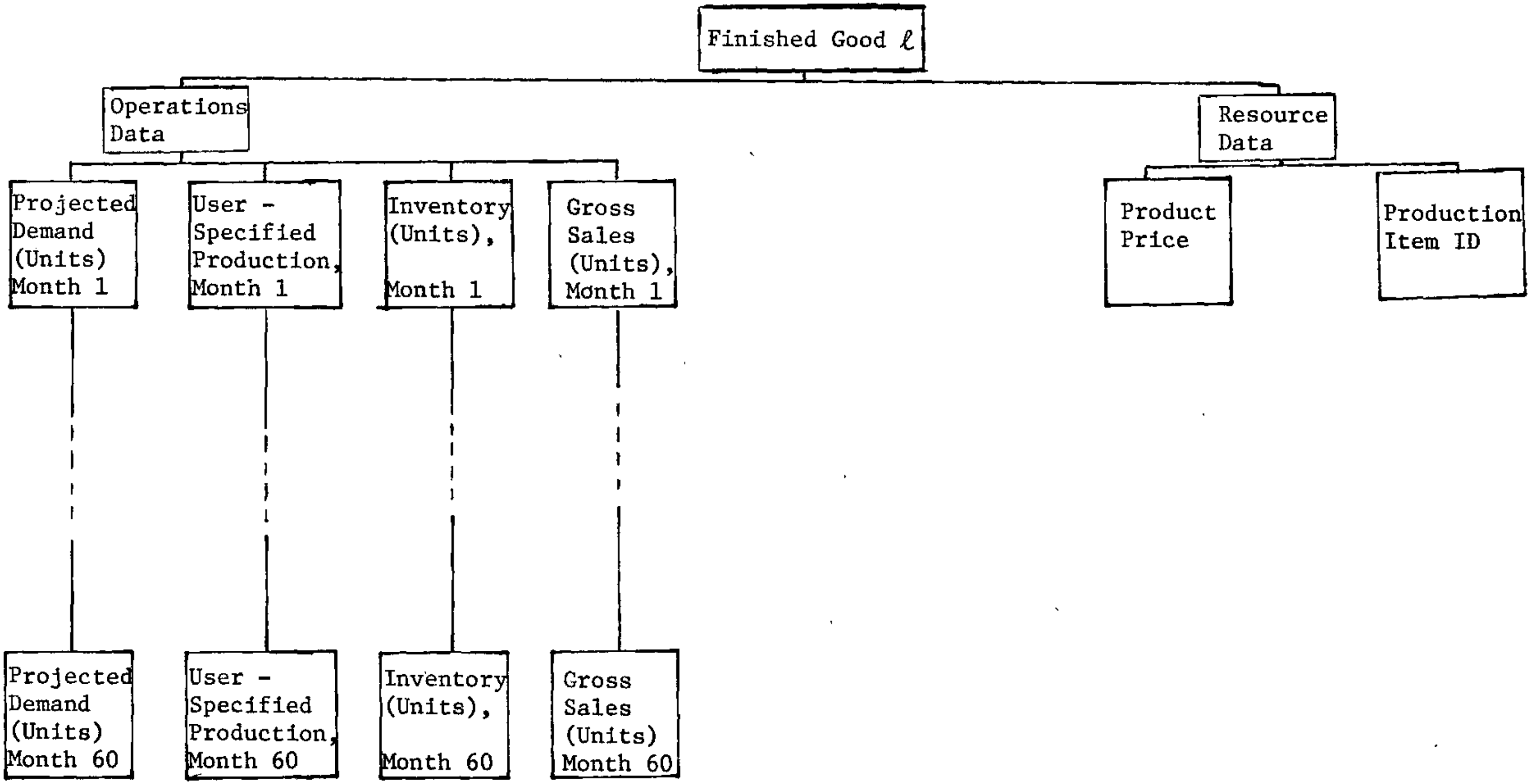

FIGURE 5.7 FINISHED GOOD DATA

user. Thus the planner need only be concerned with specifying production in relation to projected demand, and may use the model knowing the volume of finished goods that will be available for sale in a given month. The computation necessary to account for loss amounts is handled by the model, and reflected in the costs of operations during the month.

Aside from user-specified production, and demand, the finished goods operations data is generated by the model. Gross sales are expressed in units of finished goods, and are the lesser of goods available for sale (production and inventory for a given month) or amount demanded.

The production item identifier is used to relate the "finished good" to its role as a production item. For example, finished good number 2 may be production item number 1. In computations germane to the productive process, it will be referred to by its production item number (e.g., in the roll-back process), while in matters involving finished goods, it is referred to by its finished goods number. In actuality, the "ID" is a simply numerical index which allows straightforward mapping of the FG indices onto the PI indices.

Raw materials (RM) are characterized by the information depicted in Figure 5.8. The resource data stored is largely concerned with the monetary and temporal costs of raw materials acquisition. The fixed order cost and order lead time allow for the expression of all costs associated with the process of ordering. The cost per unit completes the costing of purchases, which must be at or above the minimum order quantity. Operations data is composed of units used in a given month, end-of-month inventory, the units which become available (are received) in the month, and the units which are ordered at the beginning of the

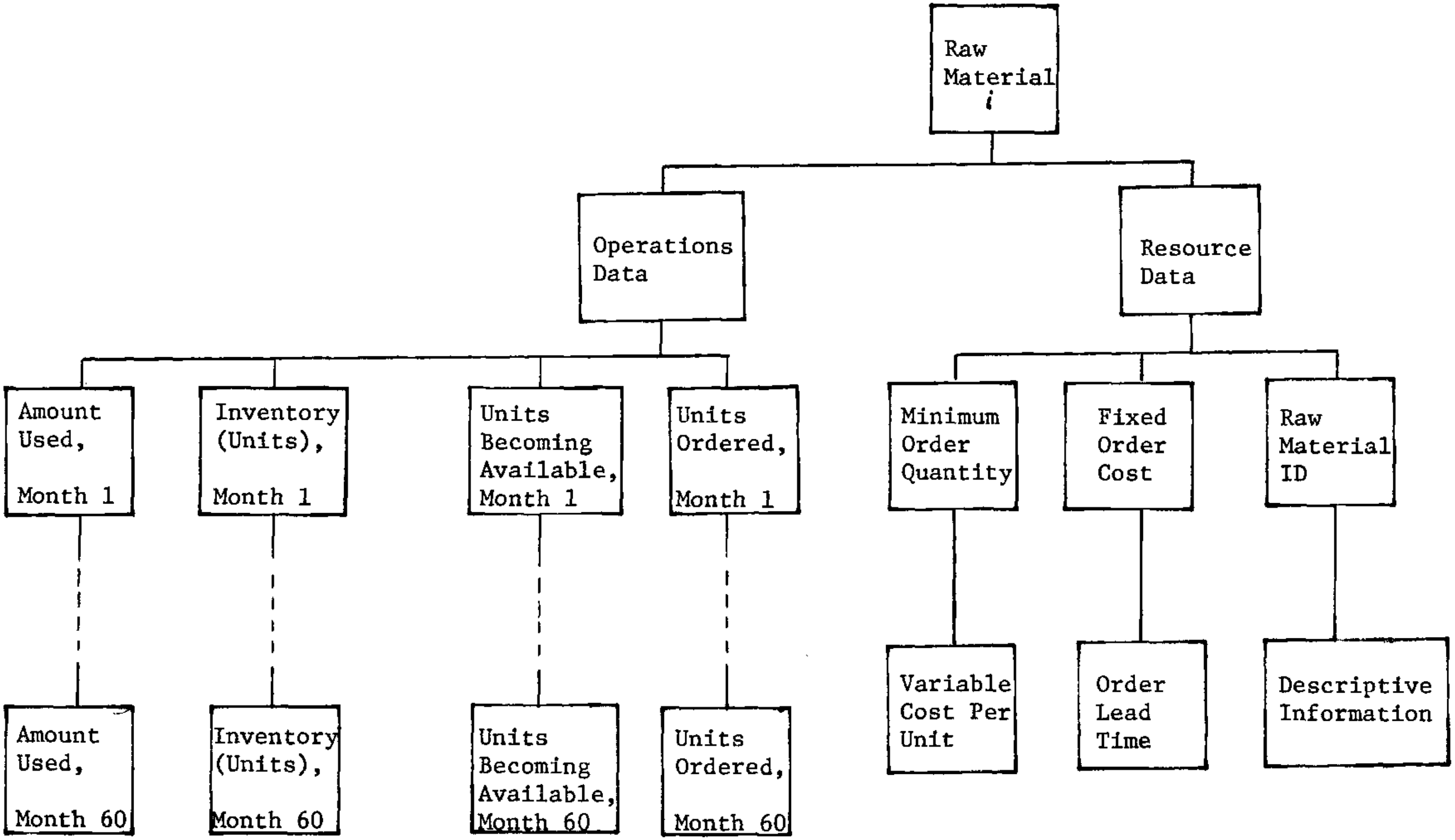

FIGURE 5.8 RAW MATERIALS DATA

month.

As mentioned above, the work force is divided into skill classes (Figure 5.9). With each skill class is associated a productivity index and wage rates for regular and overtime work[1]. The five items shown which are not associated with a particular skill class set the parameters of the work environment. They are self-explanatory, with the exception of "long-run overtime" and "minimum workforce contract period" which were defined in the previous chapter.

All of the above data are of the resource variety. As mentioned previously in this chapter, operations data needed to describe labor activity are associated with each process step. Aggregation of this information, to generate reports on labor costs or usage for the firm as a whole, entails a summation across all process steps.

The foregoing material illustrates the kind of information (resource data) required to describe a given manufacturing situation, and the forms in which operations data is collected. It must be emphasized that the use of the term process step does not necessarily imply a particular sequence of operations. Appropriate characterization of steps and produced items will allow modeling of a wide range of specialized production sequences.

As an example, suppose a firm is expected to manufacture a single product, which moves between work stations A, B, and C in the

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[1]Cases where employees receive a salary may be treated by assigning an overtime wage rate of zero.

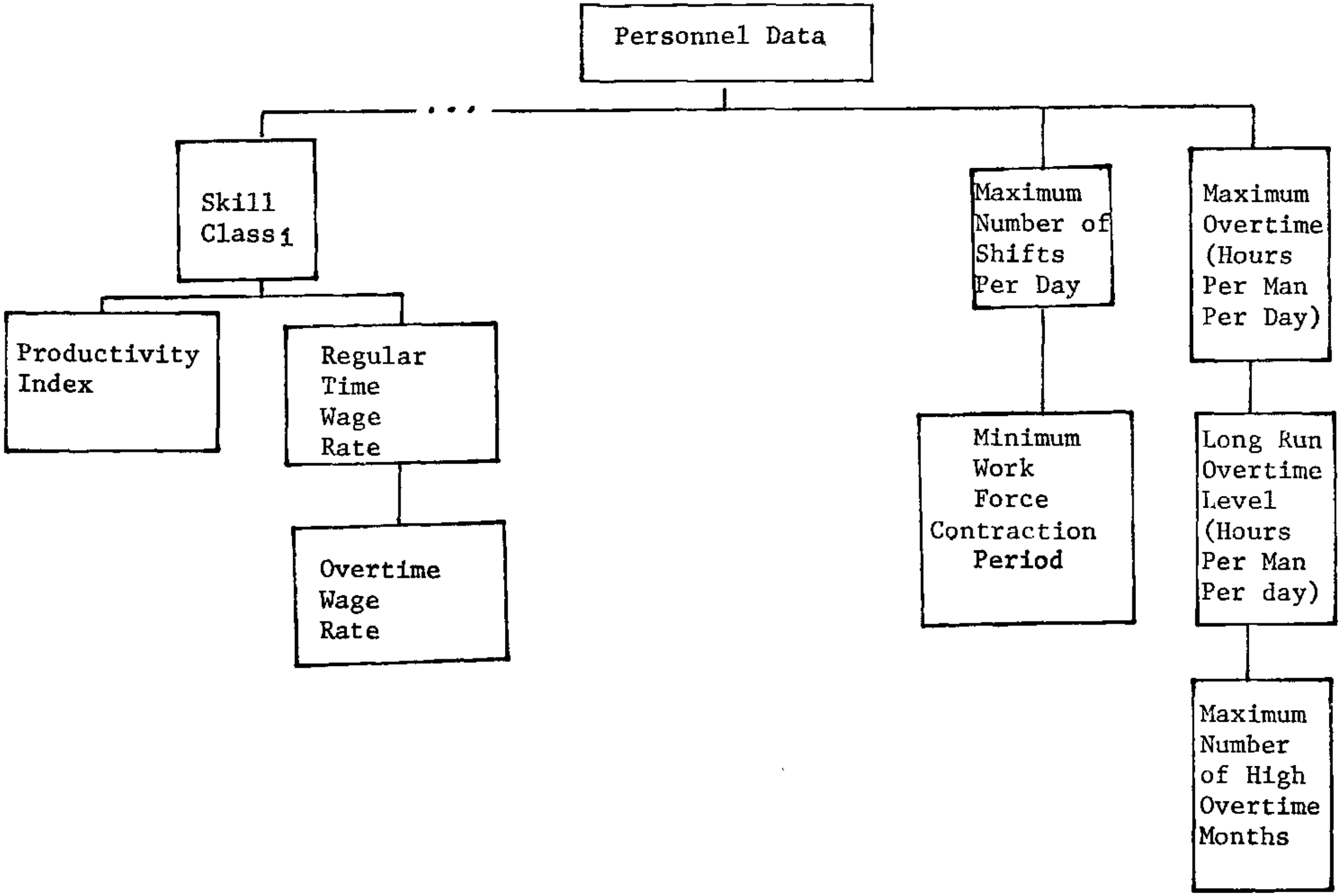
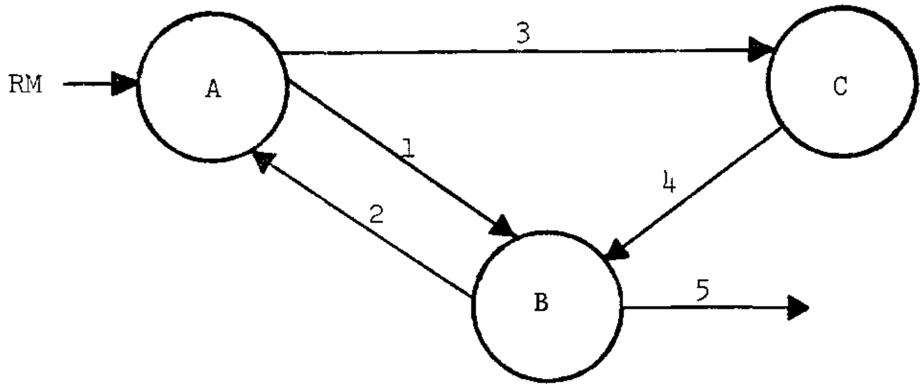


FIGURE 5.9 PERSONNEL DATA

following manner (numbers on arcs indicate precedence):



This situation can be handled by labeling the output from each visit to each work station as a distinct production item. The stations then become process steps. Table 5.1 below contains a description of this manufacturing setup as it would be represented for use with the model.

Table 5.1 Sample Manufacturing Process

Production Item	Process Stage	Input: PI/RM	Finished Good
B5	B	C4	1
C4	C	A3	
A3	A	B2	
B2	B	A1	
A1	A	Rm	

As the table shows, precedence relationships are established by the PI/RM input data stored with each PI description. Thus, multiproduct situations may be easily handled since the series of operations leading to the completion of each type of finished good is implicit in the specification of the components of the good itself.

This "macro-simulation" approach to modeling avoids the attempted simulation of individual units of production or minute transfers of information. The design philosophy used is to model the flows and activities of the productive system as initiated by user-specified production plans. Morphological idiosyncrasies of particular productive processes and equipment are circumvented via the treatment of only certain important characteristics.

5.2.1 Limits on Problem Size

Having defined the types of data used, and the manner in which they are aggregated, the question of the problem size which the model handle may now be addressed. As implemented on the computer, the following bounds on input data are in effect:

Maximum number of:

Process configurations	30
Process steps	15
Alternative configurations for any step	3
Skill classes	6
Energy/Utility types	4
Production items	20
Inputs to any item	10
Items designated as being finished goods	5
Raw materials	20

Time units	months
Length of planning period	60

It is readily apparent that the bounds are not consistent in a maximal sense: e.g., for the limits given on the number of process steps and alternative configurations there should be 45 process configurations. This reflects the belief that, in any given application, there would probably not be three different equipment alternatives for every productive activity. A similar viewpoint regarding assignment of reasonable limits is the basis for the other upper bounds specified.

5.3 Model Components

Activities required for the generation of the operations data[1] described compose the Materials and Production Subsystem. Thus its function largely consists of implementing the roll-back procedure. Modifications in production schedules and production rates are effected by use, respectively, of scrap and reject rates, and difficulty and productivity indices. Information regarding operations is stored for later processing by the Financial Subsystem. This allows effects of activities in the present on past periods (e.g., purchases in the past of capacity needed in the present, to allow for setup time) to be accounted for without rerunning the model.

The Financial Subsystem is primarily concerned with bookkeeping activities. Flows of monetary resources are calculated for each month, based on activities and transactions during the month. This information replaces monthly data for the previous month, and is used to update data accumulations for quarterly, annual, and end of planning period reporting. This process is illustrated in Figure 5.10.

The Decision Subsystem is an aggregation of modules (subroutines) used to implement decisions. Figure 5.11 shows the decision modules which this system contains.

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[1]With the exception of finished goods demand and user-specified production which are model input.

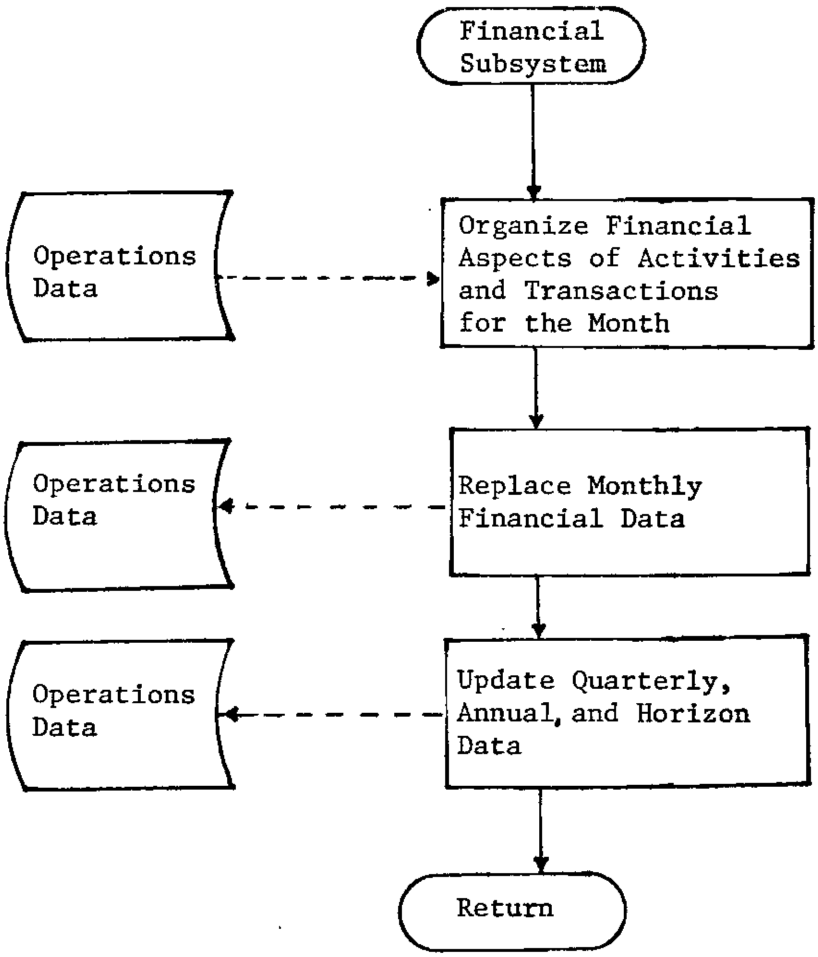


FIGURE 5.10

FINANCIAL SUBSYSTEM

The Capital Expansion Module consists of analytical steps necessart to implement needed capital expansion. Capacity must be sufficient to meet production schedules for finished goods. Expansion will take place using given incremental investment options. This is necessary to avoid an internal decision as to which finished goods production to curtail. This process (Figure 5.12) is initiated by information from the employment module indicating that capacity is insufficient. The action then taken is to add the needed capacity. If available alternatives prove insufficient, user action is required: either a decrease in production of selected finished goods, or specification of more capacity is a given process step.

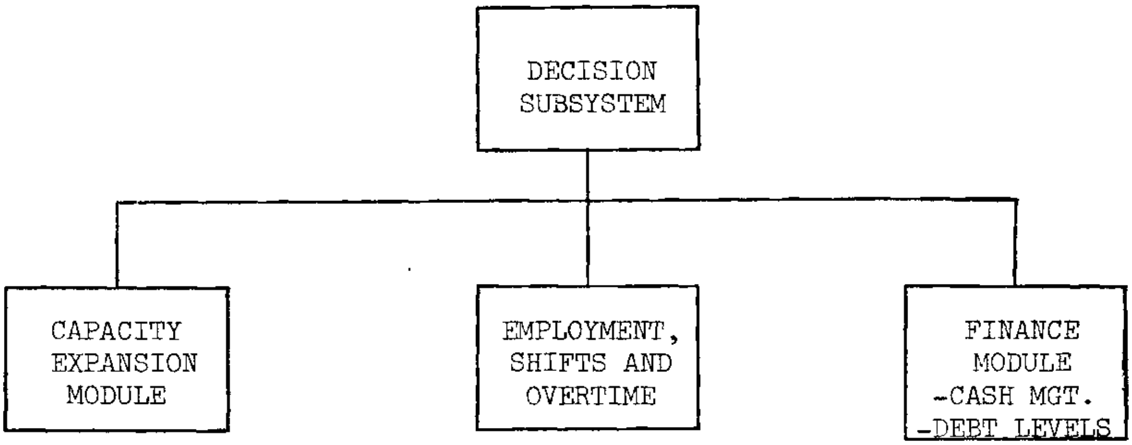


Figure 5.11 Decision Subsystem

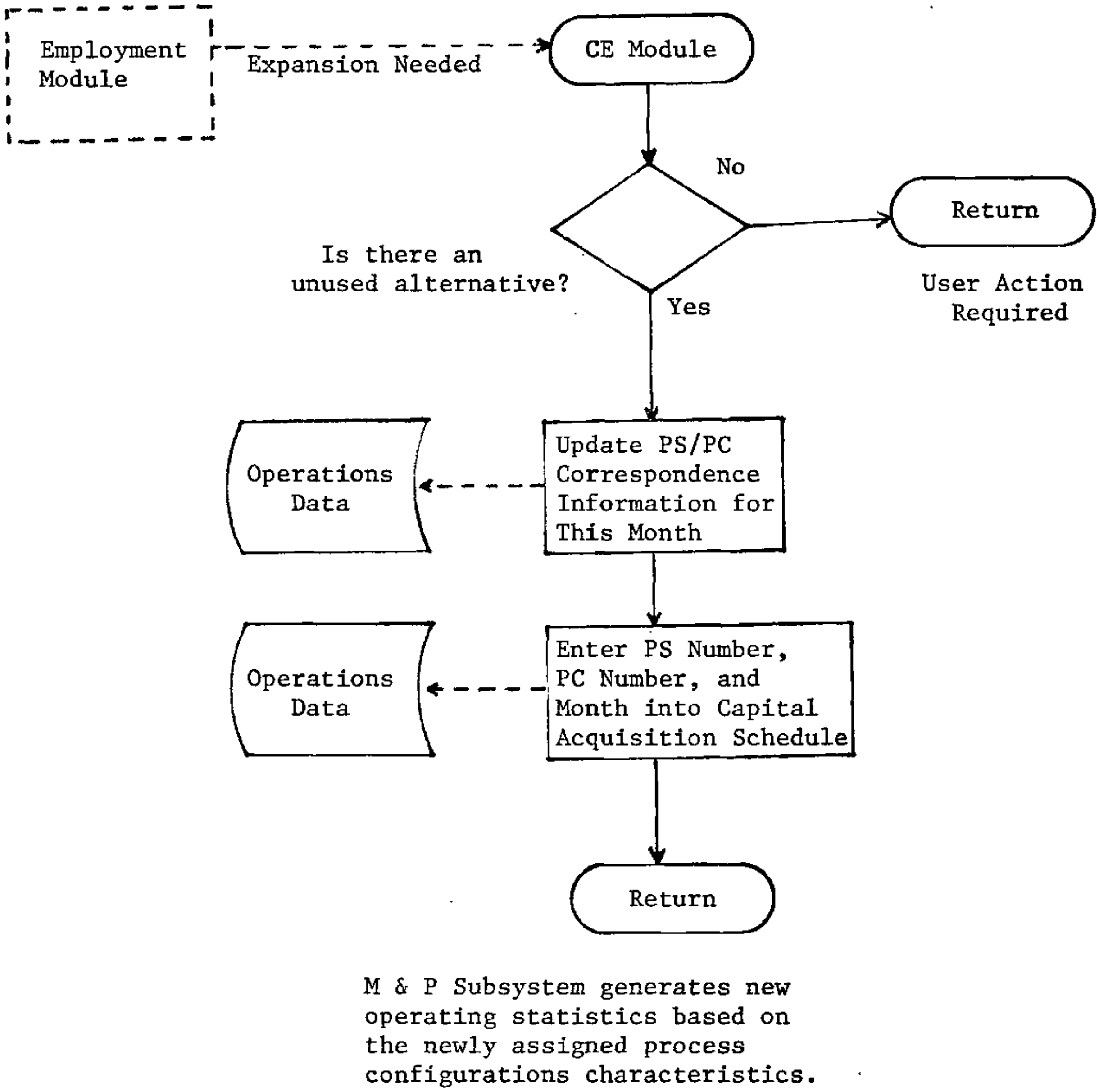


FIGURE 5.12

CAPITAL EXPANSION MODULE

Staffing levels and equipment specification are modified in response to scheduled machine run-time as designated by the Materials and Production Subsystem. If the number of operating hours scheduled exceeds a single regular shift-month the decision is made regarding overtime, shift increases or capital expansion. The mechanics of the decision process (Figure 5.13) are regulated by the criterion that every effort be made to utilize the current configuration. Given that a particular configuration is used in a particular process step, replacement of this PC by one of higher capacity occurs only if the number of hours needed by this PC to produce assigned production quantities would:

1) require more than the maximum allowable number of overtime hours on the maximum number of shifts, or,
2) require more than the maximum permissable number of consecutive high (above long-run levels) overtime months on the maximum number of shifts.

The rationale behind this approach is as follows. The typical new venture planner/manager must be acutely aware of cash flow consideratioa. It is therefore reasonable to assume that he would be willing to postpone large outlays for capital acquisition, if avoidance of these expenditures would not compromise the framework of policy and physical limitations in which his business operates.

In the case where the number of hours required is less than the number of regular time hours for the number of shifts being used, the number of shifts will be decreased unless:

1) there is only one shift being used, or
2) the number of months since the last shift increase is less

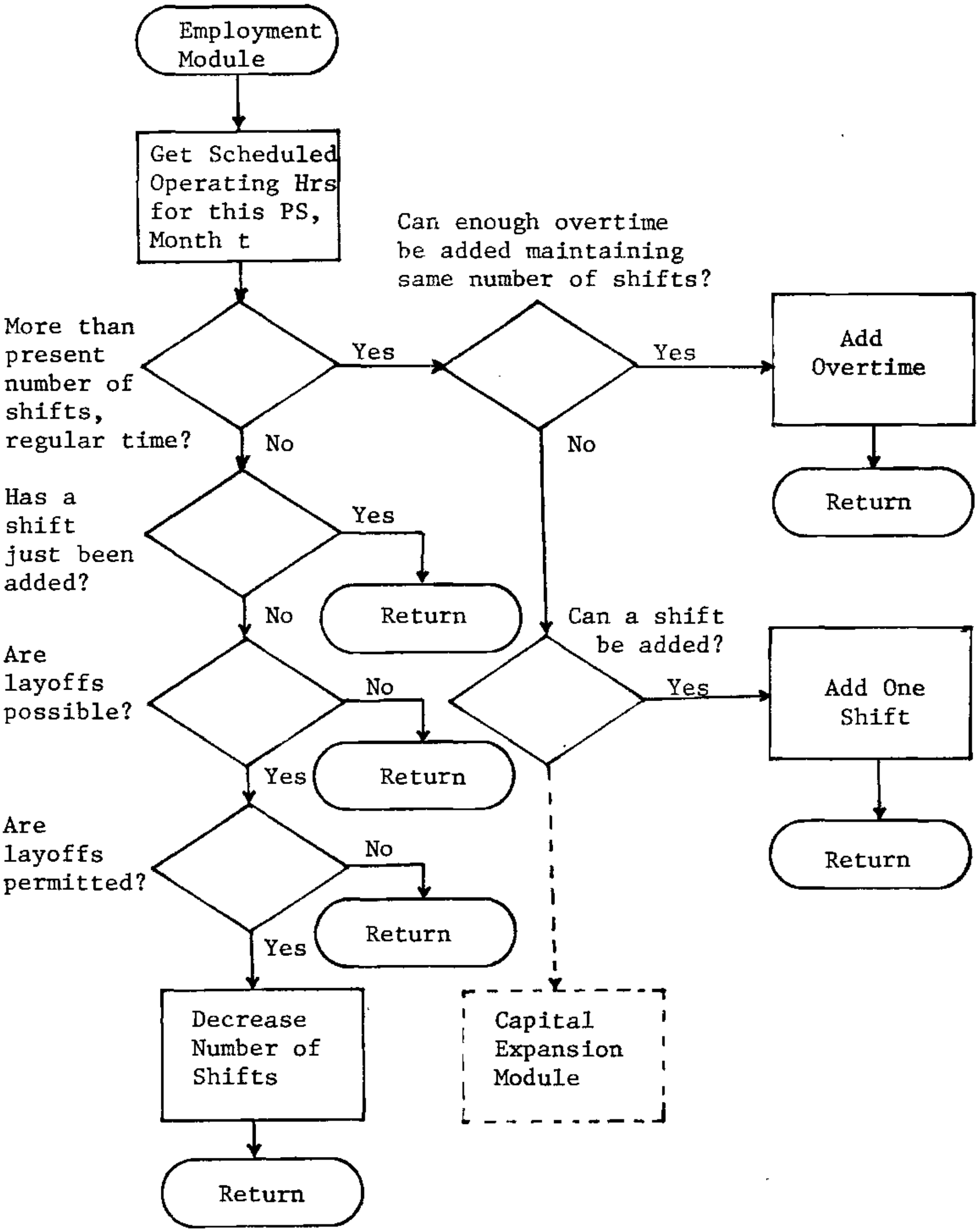


FIGURE 5.13

EMPLOYMENT MODULE

than the minimum contraction period.

The Financial Decision Module (Figure 5.14) is composed of cash and debt management functions. Simple decision rules are modeled as a part of this module. The module will borrow as dictated by cash flow in a given month and the desired cash cushion and debt-mandated cash reserves. If the month's net cash flow exceeds the minimum amount needed for compensating balance or transactions purposes, it will be used to retire outstanding debt.

5.4 Elements of Logic Structure and Equational Form

In the remainder of this chapter, the equations and logical constructs which govern the transformation of user-entered data into pro forma operating information are examined. This is in no way an attempt to illustrate and explain all of the multitudinous calculations and flows of control which compose the program form of the model (Appendix B). Only those items most essential to an overall understanding of model functioning will be presented. Discussion of financial report generation is contained in Chapter VI.

5.4.1 Scheduling of Production

It is assumed that the total time necessary to convert purchased materials into any desired quantity of finished goods is no more than one month. Therefore, receipts of materials and production of intermediate production items can all occur in the month that the finished goods whose production they support are produced. The approach taken here, while it may not be realistic for some industries, is believed to be the preferred choice, particularly in view of the exploratory

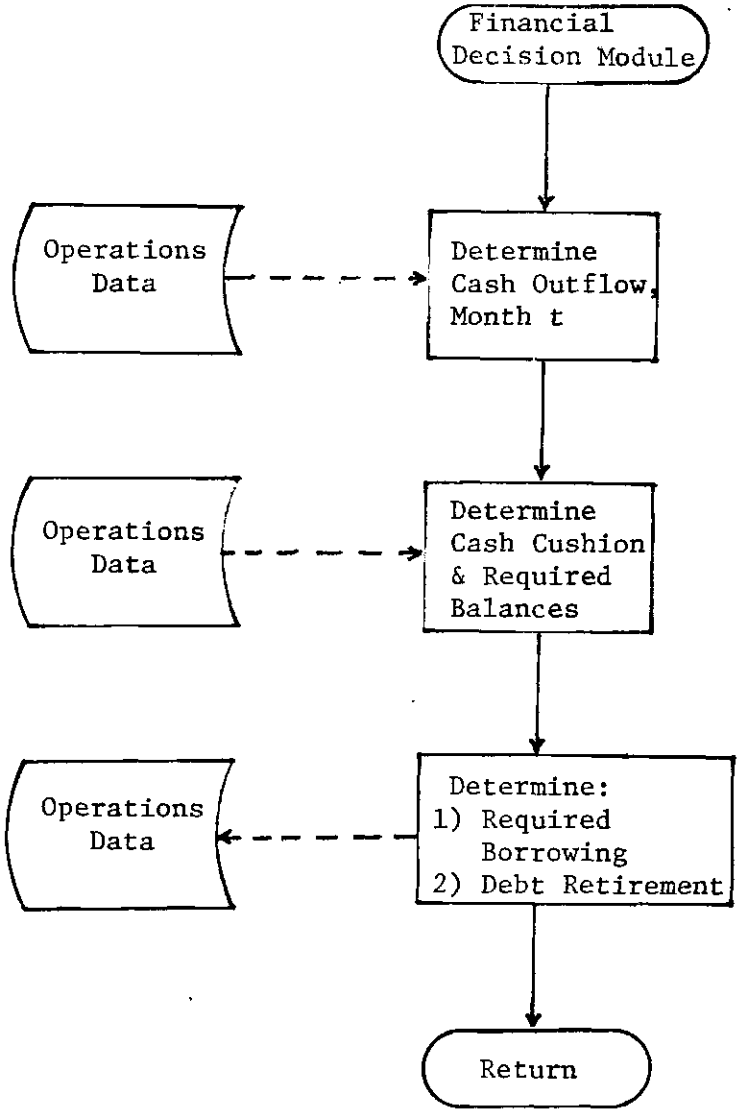
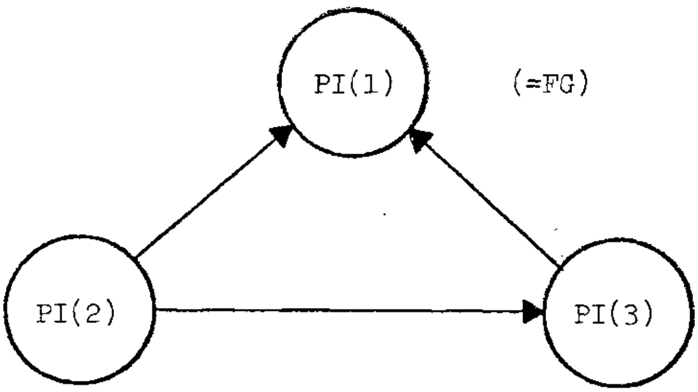


FIGURE 5.14

FINANCIAL DECISION MODULE

nature of the present work since it greatly simplifies the logic and computational requirements of the model.

As noted earlier, production items and data regarding their component parts compose the model's precendence relation information. The roll-back procedure is used to establish needed levels of production of the various items. If the user were permitted to enter PI's in an arbitrary order, a situation might arise similar to the one shown below:



Here, PI(2) and PI(3) are inputs to PI(1), and PI(2) is also an input to PI(3). Since the roll-back would start with the finished good (PI(1)) production requirements for 2 and 3 to support (directly) finished good production would be simultaneously set. Another pass would be required to establish the additional production of PI(2) needed to support production of PI(3). Expanding this example to include multiple finished goods composed of numerous interdependent PI's would greatly increase the complexity of the problem and thus adversely affect model processing speed.

A solution may be found to this difficulty by placing a restriction on the order of input of PI's, and hence the internal numbering assigned to them. It is necessary that they be ordered so that, if numbered in ascending order, no PI has as an input a PI which is assigned a lower number: i.e., a PI that precedes it in the order of input. While this does impose an added burden on the model user, for most analyses within the scope of envisioned model usage, this should not be very difficult. Any difficulty which might arise can be greatly reduced by the method described below which is an adaptation of Jackson's [31] method for schematic representation of assembly line operations.

The procedure requires that PI's be placed on descending levels (see Table 5.2) of a tabular form. Items placed in level 1 would be those that are used as inputs to no other item, and they therefore would compose the list of finished goods. On succeeding levels are entered those items which are inputs to those items already entered on higher levels. Thus no item requires as input any PI on the same or higher level. As a consequence of this, the last (lowest) level would be composed of raw materials, although some RM's may be placed on higher levels: the only restriction is that they appear at least one level below any PI's for which they are inputs.

The PI input sequence now reduces to starting from the top level and working down. Items in a given level may be entered in arbitrary order since, by construction, no intra-level precedence relations exist. The MVPM internally assigns numbers to the PI's in the order in which they are entered. Assuming that proper ordering has been observed, the roll-back process begins with the evaluation of the first PI (PI(1))

Table 5.2 Tabular Form for Sequencing of Production Items

Input Level	Production Items/Raw Materials
1: Finished Goods	
2	
3	
4	
5	
6	

and proceeds through until the last PI has been treated. Implicit in the above discussion have been the assumptions that

1) No finished good can be an input to any other production item. This may appear restrictive of a firm which sells intermediate items to allow customers to keep spare parts, etc. This difficulty can be circumvented by creating a second production item, composed of identical inputs, and designating it as a finished good.

2) No cycles are permitted: i.e., no item may be a direct or indirect input to any item that it requires as an input. This problem should not arise except in the case of a user input error. The model checks for such errors.

5.4.2 Process Step Operations

The total production time for a process step in a given month is the sum of the total number of hours that the step was actually utilized and the number of hours that it was down. The number of hours utilized must be sufficient to produce the scheduled number of units of each PI produced on this step. The derivation of these quantities is shown below.

$$MINPD_{pc'} = \min_{sc} \{PRINDX_{sc} \times (1 - PCDFAC_{pc',sc})\} \qquad (5\text{-}1)$$

$$HRSUTL_{ps,t} = \frac{\sum_{pi=1}^{N} \delta_{pi,ps} \times SCHPD_{pi,t} \times MCHDF_{pi}}{MAXOR_{pc'} \times MINPD_{pc'}} \quad (5\text{-}2)$$

$$HRSDN_{ps,t} = AVGDN_{pc'} \times \frac{HRSUTL_{ps,t}}{(1-AVGDN_{pc'})} \quad (5\text{-}3)$$

$$TOTPH_{ps,t} = HRSUTL_{ps,t} + HRSDN_{ps,t} \quad (5\text{-}4)$$

where

$MINPD_{pc'}$ = smallest multiple of skill class productivity index and labor difficulty factor for skill class sc on process configuration pc.

$HRSUTL_{ps,t}$ = hours utilized in process ps in month t.

$HRSDN_{ps,t}$ = hours down in process step ps in month t.

$PRINDX_{sc}$ = productivity index for skill class sc (PRINDX = 1 => normal productivity).

pc' = process configuration used in process step ps in month t.

$PCDFAC_{ps',sc}$ = labor difficulty factor associated with use of skill class sc on process configuration pc' ($PCDFAC_{pc',sc} \in (-\infty,1]$, $PCDFAC_{pc,sc} = 0$ = > normal difficulty).

N = number of production items.

$SCHPD_{pi,t}$ = scheduled unit production of production item pi in month t.

$$\delta_{pi,ps} = \begin{cases} 1 & \text{if item pi is produced on step ps} \\ 0 & \text{otherwise} \end{cases}$$

$MAXOR_{pc}$ = "maximum" output for process configuration pc.

$MCHDF_{pi}$ = mechanical difficulty factor associated with production of production item pi ($MCHDF_{pi} \in [0,\infty)$, $MCHDF_{pi} = 1 \Rightarrow$ normal difficulty).

$AVGDN_{pc'}$ = average percent total downtime for process configuration pc'.

$TOTPH_{ps,t}$ = total process step ps operating hours, month t.

Equation (5-1) defines the limiting combination of low productivity and high difficulty associated with one of the skill classes needed to operate the configuration used in process step ps. Its division into the operating hours determined purely from mechanical considerations (Equation 5-2)) allows the total production hour figure (Equation 5-4)) to reflect labor characteristics.

As Equation (5-5) shows, surplus capacity occurs as a result of insufficient production hours to equal or exceed one regular time shift month for the number of shifts being used in the current month[1].

$$SURCAP_{ps,t} = \text{Max}\ \{0,\ [(173.2 - \frac{TOTPH_{ps,t}}{SHFCNT_{ps,t}}) \times MAXOR_{pc'} \times (1-AVGDN_{pc'}) \times MINPD_{pc'}]\} \qquad (5\text{-}5)$$

---

1 $173.2\ \frac{\text{hours}}{\text{month}} = \frac{52 \text{ weeks/year} \times 40 \text{ work hours/week}}{12 \text{ months/year}}$

where

$SURCAP_{ps,t}$ = Surplus capacity in process step ps for month t. Measured in the same (item) units used to define the "maximum" output rate for configuration pc'.

$SHFCNT_{ps,t}$ = Number of shifts per day used in process step ps for month t.

Care must be taken in the specification of the maximum machine (configuration) output rate. This is particularly true in the case where there exists a great disparity in processing speed for different production items produced on the same process step. While consistent sets of maximum output rates and mechanical difficulty factors will yield the same operating hour and downtime information, meaningful interpretation of the surplus capacity figure rests entirely on proper valuation of the maximum output rate. This is because determination of excess capacity cannot take into account the mechanical difficulty factor associated with items produced on the step in question. To see why this is true, one need only consider a two finished good case with different rates of use of various input items. The actual capacity in any month would be dependent upon the user specified production mix. If the mix in each month were used to weight application of difficulty factors, then inter-month comparability would be lost. Additionally, any a priori assumption used to incorporate the difficulty factors into surplus capacity determination would be fallacious in the dynamic environment which is the intended setting for model use.

The maximum output rate must therefore be defined in terms of some "standard" item, using that item which has the lowest production rate. A numerical example which illustrates this issue is given in Chapter VII.

5.4.3 Material Loss and Input Requirements

As dictated by the roll-back process, sufficient inputs to and total production of an item are scheduled so that, after the effects of material loss, the needed quantity of usable product is produced. The requisite production amounts and resultant loss amounts are computed as shown below[1].

Let $PI_{pi'}$ be a direct input to production item PI_{pi} (pi < pi' or, equivalently, PI_{pi} is on a higher level than $PI_{pi'}$, where "level" is as defined in section 5.4.1). Further, let pc and pc' be indices of the process configurations used, in month t, in the process steps on which PI_{pi} and $PI_{pi'}$ are respectively, produced. The amount of item pi' needed to support production of item pi is the sum of the base production amount, $PBASE_{pi',pi,t}$, and loss amount, $AMLOSS_{pi',pi,t}$:

$$PBASE_{pi',pi,t} = SCHPD_{pi,t} \times INQTY_{pi,pi'} \tag{5-6}$$

$$SCRAPR_{pi',pi,t} = INSCP_{pi,pi'} \times (1 + AVGXSC_{pc}) \tag{5-7}$$

$$REJR_{pi',t} = AVGREJ_{pi'} \times (1 + AVGXRJ_{pc'}) \tag{5-8}$$

$$AMLOSS_{pi',pi,t} = \frac{(SCRAPR_{pi',pi,t} + REJR_{pi',t})\ PBASE_{pi',pi,t}}{(1 - [SCRAPR_{pi',pi,t} + REJR_{pi',t}])} \tag{5-9}$$

[1]Recall that production quantities of those items which are finished goods are the user-input amounts, increased to allow for rejects.

and the added reject amount from this production is

$$ADDREJ_{pi',t} = REJR_{pi,t} (AMLOSS_{pi',pi,t} + PBASE_{pi',pi,t}) \qquad (5\text{-}10)$$

where

$INQTY_{pi,pi'}$ = Units of input item pi' per unit output of item pi.

$SCRAPR_{pi,pi',t}$ = Scrap rate associated with use of item pi' in production of item pi, given use of process configuration pc.

$AVGXSC_{pc}$ = Average percent extra scrap rate over base case configuration associated with configuration pc.

$REJR_{pi',t}$ = Reject rate for production of item pi' in month t.

$AVGREJ_{pi'}$ = Average percent reject rate for production of item pi'.

$AVGXRJ_{pc'}$ = Average percent extra reject rate over base case configuration associated with configuration pc'.

Total production and reject amounts for item pi' in month t ($SCHPD_{pi',t}$ and $UNREJ_{pi',t}$ respectively) are given by

$$SCHPD_{pi't} = \sum_{pi=1}^{pi'-1} [PBASE_{pi',pi,t} + AMLOSS_{pi',pi,t}] \qquad (5\text{-}11)$$

$$UNREJ_{pi',t} = \sum_{pi=1}^{pi'-1} REJR_{pi',t} \times [PBASE_{pi',pi,t} + AMLOSS_{pi',pi,t}]$$

$$= REJR_{pi',t} \times SCHPD_{pi't} \qquad (5\text{-}12)$$

Similar computations yield the amounts of raw material $RM_{rm'}$ needed for production of scheduled quantities of item pi:

$$RBASE_{rm',pi,t} = SCHPD_{pi,t} \times INQTY_{pi,rm'} \qquad (5\text{-}13)$$

$$SCRAPR_{rm',pi,t} = INSCP_{pi,rm'} \times (1-AVGXSC_{pc}) \qquad (5\text{-}14)$$

$$SCRAP_{rm',pi,t} = \frac{SCRAPR_{rm',pi,t} \times RBASE_{rm',pi,t}}{(1-SCRAPR_{rm',pi,t})} \qquad (5\text{-}15)$$

where

$RBASE_{rm',pi,t}$ = Base usage amount of raw material rm' in production of item pi in month t.

Total usage of raw material rm' in month t ($RMUSED_{rm',t}$) is thus given by

$$RMUSED_{rm',t} = \sum_{pi=1}^{N} (RBASE_{rm',pi,t} + SCRAP_{rm',pi,t}) \qquad (5\text{-}16)$$

Where N is the total number of production items.

CHAPTER VI

COMPUTER IMPLEMENTATION

This chapter presents information on MVPM as it exists in program form. Aspects of program structure are presented, as well as details of program I/O. A thorough study of all program units and their interactions is not undertaken. Only those portions of programming which are of benefit in explaining methodology or aid in interpretation of inputs or generated reports are discussed. The reader who is interested in the details of the MVPM program is referred to the partial listing contained in Appendix B. It contains extensive internal documentation, and should not be difficult for anyone familiar with the FORTRAN language to understand.

6.1 Overall Program Organization and Flow of Control

The overall flow of control in MVPM is shown in Figure 6.1. Once within program control, the user specifies whether or not a previously saved model is to be used, or whether he wishes to create a new one. The user may then leave program control, or elect to run a simulation based on the model that he has just created or loaded. Subsequent reruns after desired changes in model data are possible. A macro flow chart of the simulation process is shown in Figure 6.2. The roll-back process is performed for each month in the planning period.

Starting with finished goods, production amounts and process operating hours for all production items and (initial) usages for all

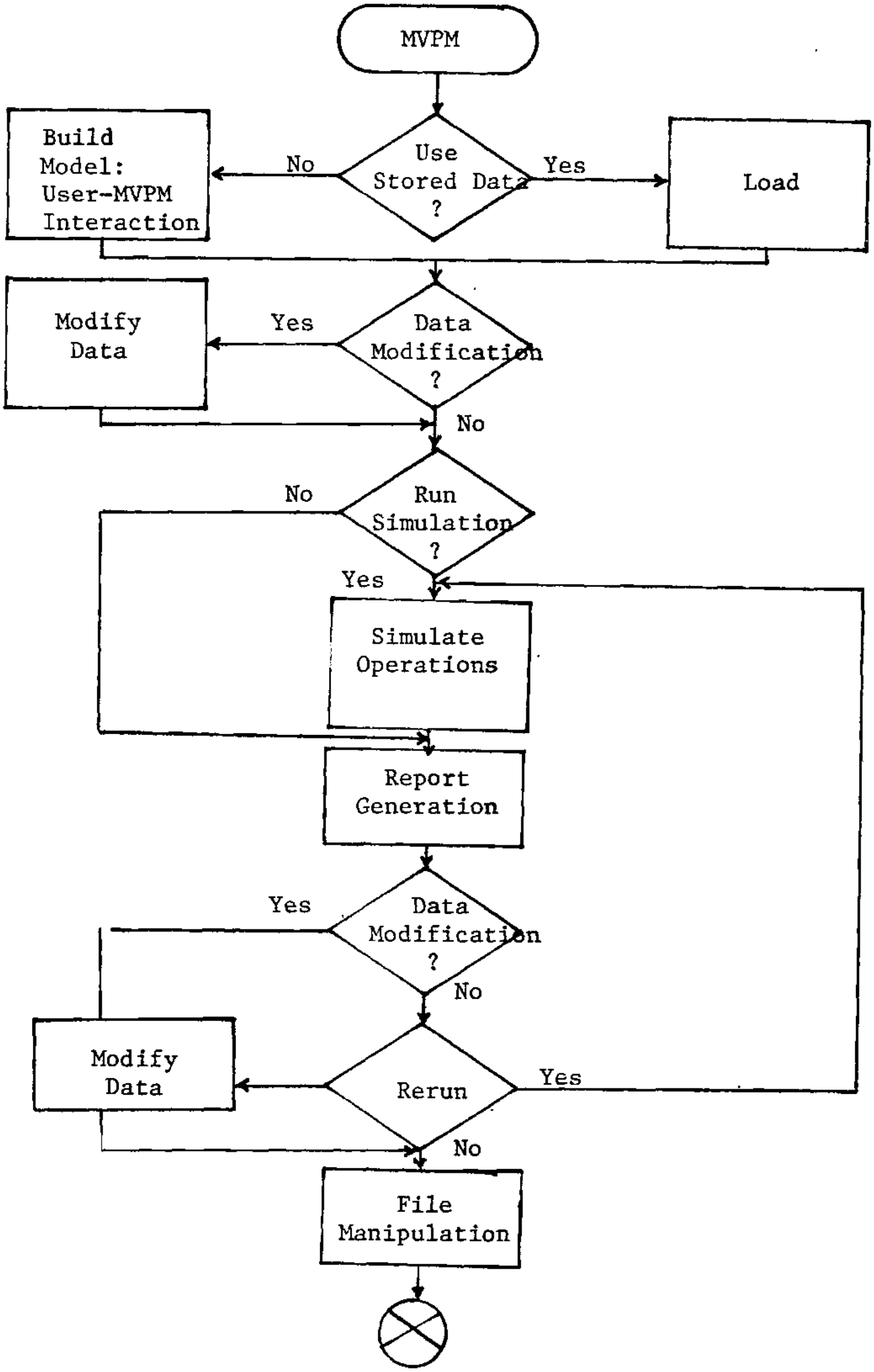


FIGURE 6.1 MVPM: FLOW OF CONTROL

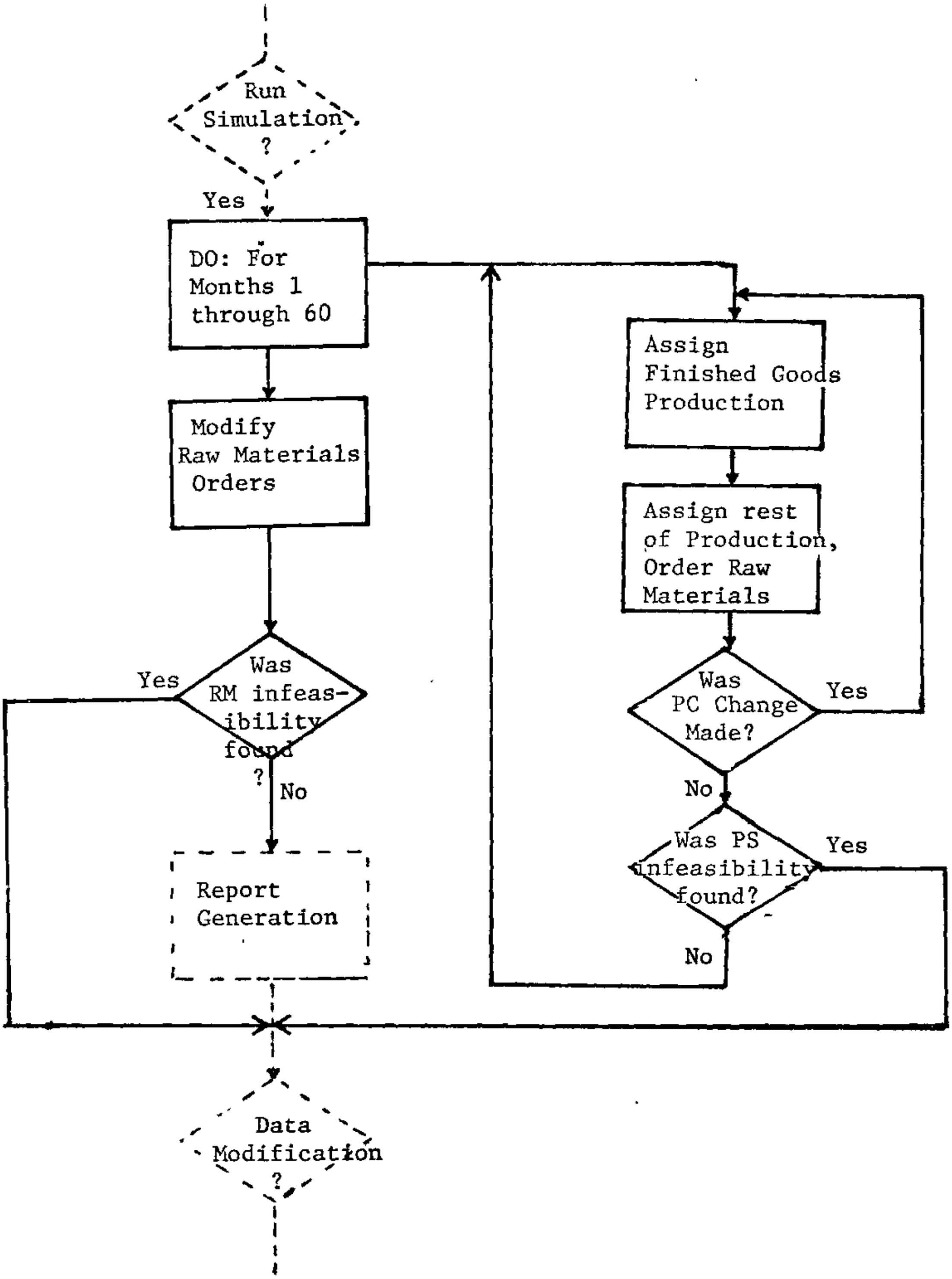


FIGURE 6.2

MVPM: SIMULATION PROCESS

raw materials are computed. Starting with the base case configuration in each process step in month 1, process steps are initially assigned the PC used in the previous month. If expansion becomes necessary (by the criteria discussed in section 5.3), operations data entries for the month are zeroed, and simulation for the month is performed again. This is done so as to fully reflect the different characteristics of the newly installed PC on resource consumption. In the event that production at a step required to meet some user specified production level exceeds the capacity of the highest capacity PC specified for this step, the simulation is terminated. A diagnostic similar to that shown in Figure 6.3 is printed at the terminal, and the user is permitted to modify data as needed.

After the manufacturing activity for all months has been set, raw material purchases are modified to reflect minimum order quantity restrictions. The algorithm employed here is illustrated in Table 6.1 and described below:

Step 1: Assign purchases as needed to satisfy requirements; taking order lead times into account. All materials ordered during startup are assumed to be available in period one. Thus, for positive lead time τ, orders to satisfy need in month(s) $t \leq \tau$ are ordered during startup and held as inventory until needed.

Step 2: Beginning with month $(60 - \tau)$, if the order quantity for a given month is less than the minimum order quantity, shift order to previous month. Table 6.1 shows the effects of this step in the transition from the column

```
DO YOU WISH TO MODIFY SELECTED DATA? (YES OR NO)
? NO



DO YOU WISH FURTHER DATA MODIFICATION AND/OR DISPLAY? (YES OR NO)
? NO

DO YOU WISH TO RERUN SIMULATION? (YES OR NO)
? YES


***NEEDED EXPANSION IS NOT POSSIBLE AT PROCESS STEP  1: SDGAR
***LARGEST PC SPECIFIED FOR USE WITH THIS PS IS: ST/DG2
***A PC WITH HIGHER CAPACITY OR A DECREASE IN MONTH  5 PRODUCTION
   MUST BE SPECIFIED.



 DO YOU WISH CURRENT MODEL TO BE STORED AS THE TEMPORARY (RUN-TIME) BASE MODEL?
 ? NO

 DO YOU WISH TO MODIFY AND/OR DISPLAY DATA?(YES OR NO)
 ? YES
```

Figure 6.3 Process Step Infeasibility Diagnostic

Table 6.1. Raw Materials Purchasing Algorithm: Example

Month	Amount Required	I New Orders: Initial Assignment	II New Orders: After 1st Pass To Satisfy MINOQ		III New Orders: After Startup Raised To 1200
Startup	-	375.00	767.50	+ 45.5 + 165.5 + 221.5 =	1200.00
1	187.50	392.50	0		0
2	187.50	392.50	1245.50		1200.00
3	392.50	392.50	0		0
4	392.50	460.50	0		0
5	392.50	614.00	1365.50		1200.00
6	460.50	751.50	0		0
7	614.00	904.50	1945.00		1723.50
8	751.00	1040.50	0		0
9	904.50	1228.00	1228.00		1228.00
10	1040.50	1365.00	1365.00		1365.00
11	1228.00	⋮	⋮		⋮
12	1365.00				
	⋮				

NOTES: 1) Minimum Order Quantity = 1200 units

2) Order Lead Time = 2 Months

I to the column labeled II. Orders are aggregated until the cumulative order in a month is over the minimum order quantity of 1200 units. As column II shows, the startup period order may still not be large enough.

Step 3: If the startup order is large enough, stop. Otherwise, beginning with month one, shift to the startup period an order whose size is the lesser of:

1) the excess over the minimum order quantity of the order in the month, or
2) the amount needed to bring the startup order up to minimum order quantity.

The transition from column II to column III in Table 6.1 illustrates this process. Only part of the excess over the minimum in month 7 was needed to satisfy minimum order quantity restrictions in the startup period.

Step 4: If the startup order is still too small, shift the entire order from a nonzero order month to the startup period, starting with month 1. Because of Step 3, all positive orders at this point will exactly equal the minimum order quantity.

If the startup order still is less than the minimum order quantity after Step 4, then all orders for the entire planning period sum to less than the specified minimum order quantity: clearly a data entry or specification error has occurred. MVPM takes actions similar to those taken for a process step infeasibility: a diagnostic is printed, and user modification of data is allowed.

Once the raw materials purchasing has been adjusted, the simulation is completed. A message is printed at the terminal to indicate this fact, and the user may then select the context and disposition of its model output. The reports which are produced are discussed further in section 6.3.

6.2 Data Entry

Data entry is generally organized along the lines of the data collections set forth in Chapter V: process steps and configurations, production items, etc. Additional classifications are provided for "energy/utility data" and "general financial data". If the user elects not to use a previously saved model during initial data entry, then all data items necessary to perform a simulation must be generated. Figure 6.4 illustrates part of this process.

The data in Figure 6.4 is for a simple model which will be used to illustrate MVPM input and output for the balance of this chapter. There are three production items - two varieties of "widget" which are finished goods, and an intermediate assembly. Raw materials used are wood and glue. There are two process steps: an assembly area and a finishing area. There are also two process configurations of different capacity. Figure 6.5 illustrates further details of the user-entered information.

The generation of schedules for finished goods demand and production, office equipment and administrative salaries, sales and marketing expense, and administrative expense is performed using the schedule generation function illustrated in Figure 6.4. The user may specify

```
********************FINISHED GOODS DATA.
INPUT NUMBER OF FINISHED GOODS
(WHOLE NUMBER BETWEEN 1 AND  5)
? 2


ENTER THE NAME OF THE PRODUCTION ITEM WHICH IS FINISHED GOOD NUMBER 1
? WIDGET1


ENTER THE NAME OF THE PRODUCTION ITEM WHICH IS FINISHED GOOD NUMBER 2
? WIDGET2

ENTER, IN ORDER, PRICE(S) ($) FOR FINISHED GOOD(S): WIDGET1    WIDGET2
(NUMBERS MUST BE SEPERATED BY COMMAS)
? 7.00 15.00




*****USER DIRECTED SCHEDULE GENERATION- SCHEDULE TYPE: DEMAND

******FINISHED GOOD NUMBER 1: WIDGET1



ENTER BEGINNING AND ENDING MONTH TO BE TREATED.
? 1 60
DO YOU WISH TO ENTER 60 NUMBERS FOR THE DEMAND
LEVEL IN EACH MONTH (POINTS), OR THE LEVEL IN MONTHS  1 AND 60, ALLOWING
THE MODEL TO CALCULATE A STRAIGHT LINE BETWEEN THEM (LINE).
===>ENTER 'POINTS' OR 'LINE'.

? LINE
ENTER DEMAND FOR MONTHS  1 THROUGH 60.
===>2 NUMBERS: FIRST- MONTH  1 DEMAND
               SECOND- MONTH 60 DEMAND
? 10 1200
IF SCHEDULE MUST BE COMPOSED OF WHOLE NUMBERS, TYPE 'YES', OTHERWISE TYPE 'NO'.
? YES

DO YOU WISH TO ENTER MORE DATA ON DEMAND    ?
(TYPE YES OR NO)
? NO
```

Figure 6.4 Demand Schedule Entry

```
-MVPRUN(MVPMOD=WIDMOD3)
```

```
********************************************************************************
          ==========> MANUFACTURING VENTURE PLANNING MODEL <==========

                    RUN DATE:  78/08/18.
********************************************************************************
```

```
********************INITIAL DATA ENTRY.


DO YOU WISH TO RUN A MODEL THAT HAS BEEN STORED ON THE COMPUTER? (TYPE YES OR NO)
? YES


DO YOU WISH A LISTING OF ALL DATA ITEMS?
(TYPE YES OR NO)
? YES


********************ENERGY/UTILITY DATA.
```

E/U NUMBER	NAME	DESCRIPTION	UNITS	COST PER UNIT
1	GAS	LIQUIFIED NATURAL GAS	CUBIC FEET	.025
2	ELEC/220	220 VOLT/FEEDER# A216; GA. POWER	KVH	.225

Figure 6.5 User-Entered Data

********************PERSONNEL DATA.

SC NUMBER	NAME	RT WAGE	OT WAGE	PRODUCTIVITY INDEX
1	LABOR	3.50	7.00	.90
2	OPERATOR	5.00	10.00	1.00
3	CRAFTSMAN	7.00	14.00	1.10

MAXIMUM NUMBER OF CONTIGUOUS HIGH OVERTIME MONTHS: 1.

MAXIMUM OVERTIME HOURS PER MAN PER DAY: 8.

ACCEPTABLE SEMI-PERMANENT OVERTIME LEVEL (HOURS/DAY): 2.

MAXIMUM NUMBER OF SHIFTS PER DAY: 2.

MINIMUM WORKFORCE CONTRACTION PERIOD- SMALLEST NUMBER OF MONTHS BETWEEN HIRE AND FIRE: 3.

********************RAW MATERIALS DATA.

RM NUMBER	NAME	DESCRIPTION	UNITS
1	PINE WOOD	GEORGIA YELLOW PINE	BRD. FEET
2	GLUE	EPOXY,2000 PSI TEST: THOMAS SUPPLY	PINTS

NUMBER	NAME	FIXED ORDER COST	VARIABLE COST PER UNIT	RM ORDER LEAD TIME	MINIMUM ORDER QUANTITY
1	PINE WOOD	1.00	.25	0.	100.00
2	GLUE	1.25	1.20	1.	15.00

Figure 6.5 cont'd

********************PROCESS CONFIGURATION DATA.

PC NUMBER	NAME	DESCRIPTION
1	TABLE-1	SMALL TABLE
2	TABLE-2	LARGE ABLE

PC NUMBER	NAME	ORDER LEAD TIME	SETUP LEAD TIME	EXPECTED LIFE	MAXIMUM OUTPUT RATE	AVERAGE TOTAL % DOWNTIME	AVG. % EXTRA OVER BASE CASE: REJECTS	AVG. % EXTRA OVER BASE CASE: SCRAP
1	TABLE-1	1.	0.	10.	10.0	0.000	0.000	0.000
2	TABLE-2	4.	1.	6.	15.0	.050	0.000	0.000

PC NUMBER	NAME	TOTAL INVESTMENT	DEPRECIABLE COST	SALVAGE VALUE	FLOOR SPACE	ENERGY/UTILITY USE PER OPERATING HOUR: GAS	ELEC/220
1	TABLE-1	125.00	100.00	10.00	60.00	0.000	0.000
2	TABLE-2	350.00	300.00	50.00	150.00	0.000	.050

PC		* LABOR		* OPERATOR		* CRAFTSMAN		*					
NUMBER	NAME	*STFG.	DIF.	*STFG.	DIF.	*STFG.	DIF.	*STFG.	DIF.	*STFG.	DIF.	*STFG.	DIF.
1	TABLE-1	* 6.	.10	* 0.	0.00	* 1.	0.00	*					
2	TABLE-2	* 3.	0.00	* 1.	0.00	* 1.	.15	*					

********************PROCESS STEP DATA.

PS NUMBER	NAME	ALTERNATIVE PROCESS CONFIGURATIONS: 1	2	3
1	ASSY AREA	TABLE-1	TABLE-2	
2	FIN AREA	TABLE-2		

Figure 6.5 cont'd

********************PRODUCTION ITEM DATA.

PI NUMBER	NAME	DESCRIPTION	MECH. DIF. FACTOR	AVG. % REJ. RATE	PRODUCED ON PS:
1	WIDGET1	STANDARD WIDGET, SINGLE VERSION	1.00	.050	FIN AREA
2	WIDGET2	STANDARD WIDGET, DOUBLE VERSION	1.20	.050	FIN AREA
3	ASSEMBLY	INTERMEDIATE ASSEMBLY	1.00	.070	ASSY AREA

PI NUMBER	NAME	INPUT NAME	INPUT QTY. PER UNIT OF OUTPUT	INPUT SCRAP RATE IN PRODUCTION OF OUTPUT
1	WIDGET1	GLUE	.20 PINTS	.020
		ASSEMBLY	2.00 ASSY'S	0.000
2	WIDGET2	PINE WOOD	5.00 BRD. FEET	.050
		ASSEMBLY	2.00 ASSY'S	0.000
3	ASSEMBLY	PINE WOOD	14.50 BRD. FEET	.150
		GLUE	.50 PINTS	.176

********************FINISHED GOODS DATA.

FG NUMBER	FG/PI NAME	PRICE
1	WIDGET1	75.00
2	WIDGET2	110.00

Figure 6.5 cont'd

	1 WIDGET1		2 WIDGET2		
MONTH	DEMAND	USER INPUT PRODUCTION	DEMAND	USER INPUT PRODUCTION	DEMAND
1	10.00	250.00	200.00	100.00	
2	30.00	264.00	219.00	122.00	
3	50.00	279.00	237.00	144.00	
4	71.00	293.00	256.00	166.00	
5	91.00	308.00	275.00	188.00	
6	111.00	322.00	293.00	210.00	
7	131.00	336.00	312.00	232.00	
8	151.00	351.00	331.00	254.00	
9	171.00	365.00	349.00	276.00	
10	192.00	380.00	368.00	298.00	
11	212.00	394.00	386.00	320.00	
12	232.00	408.00	405.00	342.00	
13	252.00	423.00	424.00	364.00	
14	272.00	437.00	442.00	386.00	
15	292.00	452.00	461.00	408.00	
16	313.00	466.00	[illegible]	431.00	
17	333.00	481.00	498.00	453.00	
18	353.00	495.00	517.00	475.00	
19	373.00	509.00	536.00	497.00	
20	393.00	524.00	554.00	519.00	
21	413.00	538.00	573.00	541.00	
22	434.00	553.00	592.00	563.00	
23	454.00	567.00	610.00	585.00	
24	474.00	581.00	629.00	607.00	
25	494.00	596.00	647.00	629.00	
26	514.00	610.00	666.00	651.00	
27	534.00	625.00	685.00	673.00	
28	555.00	639.00	703.00	695.00	
29	575.00	653.00	722.00	717.00	
30	595.00	668.00	741.00	739.00	
31	615.00	682.00	759.00	761.00	
32	635.00	697.00	778.00	783.00	
33	655.00	711.00	797.00	805.00	
34	676.00	725.00	815.00	827.00	
35	696.00	740.00	834.00	849.00	
36	716.00	754.00	853.00	871.00	
37	736.00	769.00	871.00	893.00	
38	756.00	783.00	890.00	915.00	
39	776.00	797.00	908.00	937.00	
40	797.00	812.00	927.00	959.00	
41	817.00	826.00	946.00	981.00	
42	837.00	841.00	964.00	1003.00	
43	857.00	855.00	983.00	1025.00	
44	877.00	869.00	1002.00	1047.00	
45	897.00	884.00	1020.00	1069.00	
46	918.00	898.00	1039.00	1092.00	
47	938.00	913.00	1058.00	1114.00	
48	958.00	927.00	1076.00	1136.00	
49	978.00	942.00	1095.00	1158.00	
50	998.00	956.00	1114.00	1180.00	
51	1018.00	970.00	1132.00	1202.00	
52	1039.00	985.00	1151.00	1224.00	
53	1059.00	999.00	1169.00	1246.00	
54	1079.00	1014.00	1188.00	1268.00	
55	1099.00	1028.00	1207.00	1290.00	
56	1119.00	1042.00	1225.00	1312.00	
57	1139.00	1057.00	1244.00	1334.00	
58	1160.00	1071.00	1263.00	1356.00	
59	1180.00	1086.00	1281.00	1378.00	
60	1200.00	1000.00	1300.00	1300.00	

Figure 6.5 cont'd

**********************GENERAL FINANCIAL DATA.

PERCENT UNCOLLECTABLES (EXPRESSED AS A FRACTION OF GROSS SALES): .60
PLANT BUILDING MONTHLY RENT ($ PER S.F.): 4.00
PLANT OH ($ PER SCHEDULED PS OPERATING HOUR): .50
INITIAL EQUITY AMOUNT ($): 10000.00

EFFECTIVE ANNUAL INTEREST RATE: .11
PAYROLL TAXES AND FRINGE BENEFITS (AS FRACTION OF TOTAL PAYROLL): .05
CORPORATE INCOME TAX RATE: .26
CORPORATE INCOME SURTAX RATE: .22
INCOME BREAKPOINT OVER WHICH SURTAX APPLIES ($): 50000.00

COST OF HIRING (AS FRACTION OF MONTHLY RT WAGE): .25
COST OF FIRING (AS FRACTION OF MONTHLY RT WAGE): .10
MINIMUM DESIRED CASH BALANCE ($): 1000.00
MIN. REQ'D CASH BALANCE (AS FRACTION OF OUTSTANDING DEBT): .10

STARTUP LOAN AMOUNT ($): 10000.00
AD VALOREM TAX RATE ON EQUIPMENT HAS FRACTION OF BOOK VALUE): .05
AD VALOREM TAX RATE ON INVENTORY (AS FRACTION OF BOOK VALUE): .05
MINIMUM TAXABLE EQUIPMENT VALUE (AS FRACTION OF DEPRECIABLE COST): .18

MONTH	ADMINISTRATIVE SALARIES ($)	SALES & MKTG. EXPENSE ($)	OFFICE EQUIPMENT PURCHASES($)	ADMINISTRATIVE EXPENSE ($)
1	400.00	100.00	1000.00	100.00
2	418.64	115.25	0.00	101.69
3	437.29	130.51	0.00	103.39
4	455.93	145.76	500.00	105.08
5	474.58	161.02	1000.00	106.78
6	493.22	176.27	1500.00	108.47
7	511.86	191.53	0.00	110.17
8	530.51	206.78	0.00	111.86
9	549.15	222.03	0.00	113.56
10	567.80	237.29	0.00	115.25
11	586.44	252.54	0.00	116.95
12	605.08	267.80	0.00	118.64
13	623.73	283.05	0.00	120.34
14	642.37	298.31	0.00	122.03
15	661.02	313.56	0.00	123.73
16	679.66	328.81	0.00	125.42
17	698.31	344.07	0.00	127.12
18	716.95	359.32	0.00	128.81
19	735.59	374.58	0.00	130.51
20	754.24	389.83	0.00	132.20
21	772.88	405.08	0.00	133.90
22	791.53	420.34	0.00	135.59
23	810.17	435.59	0.00	137.29
24	828.81	450.85	0.00	138.98
25	847.46	466.10	0.00	140.68
26	866.10	481.36	0.00	142.37
27	884.75	496.61	0.00	144.07
28	903.39	511.86	0.00	145.76
29	922.03	527.12	0.00	147.46
30	940.68	542.37	0.00	149.15
31	959.32	557.63	0.00	150.85
32	977.97	572.88	0.00	152.54
33	996.61	588.14	0.00	154.24
34	1015.25	603.39	0.00	155.93

Figure 6.5 cont'd

35	1033.90	618.64	0.00	157.63
36	1052.54	633.90	0.00	159.32
37	1071.19	649.15	0.00	161.02
38	1089.83	664.41	0.00	162.71
39	1108.47	679.66	0.00	164.41
40	1127.12	694.92	0.00	166.10
41	1145.76	710.17	0.0C	167.80
42	1164.41	725.42	0.00	169.49
43	1183.05	740.68	0.00	171.19
44	1201.69	755.93	0.00	172.88
45	1220.34	771.19	0.00	174.58
46	1238.98	786.44	0.00	176.27
47	1257.63	801.69	0.00	177.97
48	1276.27	816.95	0.00	179.66
49	1294.92	832.20	0.00	181.36
50	1313.56	847.46	0.00	183.05
51	1332.20	862.71	0.00	184.75
52	1350.85	877.97	0.00	186.44
53	1369.49	893.22	0.00	188.14
54	1388.14	908.47	0.00	189.83
55	1406.78	923.73	0.00	191.53
56	1425.42	938.98	0.00	193.22
57	1444.07	954.24	0.00	194.92
58	1462.71	969.49	0.00	196.61
59	1481.36	984.75	0.00	198.31
60	1500.00	1000.00	0.00	200.00

```
DO YOU WISH TO MODIFY AND/OR DISPLAY DATA? (YES OR NO)
? NO
```

Figure 6.5 concluded

point-by-point data entry, or linear interpolation between two specific values, or any combination of the two. Maximum flexibility is thus combined with the reduction in data entry burden afforded by the linear interpolation routine.

Once a model file has been created, it may be modified (permanently or for a particular run) via the capabilities illustrated in Figure 6.5. The data entry process is essentially the same as that user for initial data entry, with the exception that in the modification process, only selected data are altered.

6.3 Model Output

6.3.1 Operations Reporting

The following operating reports may be obtained:

Process Step Operations Profile (and Summary)

Production Item Production Profile (and Summary)

Raw Materials Profile (and Summary)

Finished Goods Sales Profile (and Summary)

Process Step Employment Profile

Comprehensive Employment Profile

Capital Expansion Profile

Energy/Utility Usage Profile (Summary)

All Profiles are monthly, while summaries are on an annual basis. Examples of each report type are shown in Tables 6.2 through 6.9.

Table 6.2 illustrates the dynamics of an expansion of capacity. In month 35, the assembly area changes from use of TABLE-1 to TABLE-2. The effect of the percentage downtime of Table 2 is apparent, as is its

Table 6.2 Process Step Operations Profile

OPERATIONS PROFILE: PROCESS STEP- ASSY AREA

MONTH	PC USED	HOURS SCHEDULED	HOURS UTILIZED	HOURS DOWN	SHIFTS PER DAY	OT HRS PER MAN, PER SHIFT	ACTUAL OUTPUT (UNITS)	SURPLUS CAPACITY: UNITS	FRACTION OF OUTPUT
1	TABLE-1	97.8	97.8	0.00	1.	0.0	792.0	611.	.77
2	TABLE-1	107.8	107.8	0.00	1.	0.0	873.0	530.	.61
3	TABLE-1	118.4	118.4	0.00	1.	0.0	959.0	444.	.46
4	TABLE-1	128.1	128.1	0.00	1.	0.0	1038.0	365.	.35
5	TABLE-1	138.6	138.6	0.00	1.	0.0	1123.0	280.	.25
6	TABLE-1	148.6	148.6	0.00	1.	0.0	1204.0	199.	.17
7	TABLE-1	158.8	158.8	0.00	1.	0.0	1286.0	117.	.09
8	TABLE-1	168.9	168.9	0.00	1.	0.0	1368.0	35.	.03
9	TABLE-1	179.3	179.3	0.00	1.	6.1	1452.0	0.	0.00
10	TABLE-1	189.5	189.5	0.00	1.	16.3	1535.0	0.	0.00
11	TABLE-1	199.6	199.6	0.00	1.	26.4	1617.0	0.	0.00
12	TABLE-1	209.5	209.5	0.00	1.	36.3	1697.0	0.	0.00
13	TABLE-1	219.9	219.9	0.00	1.	46.7	1781.0	0.	0.00
14	TABLE-1	229.9	229.9	0.00	2.	0.0	1862.0	472.	.25
15	TABLE-1	240.4	240.4	0.00	2.	0.0	1947.0	429.	.22
16	TABLE-1	250.9	250.9	0.00	2.	0.0	2032.0	387.	.19
17	TABLE-1	261.0	261.0	0.00	1.	87.8	2114.0	0.	0.00
18	TABLE-1	271.0	271.0	0.00	2.	0.0	2195.0	305.	.14
19	TABLE-1	281.2	281.2	0.00	2.	0.0	2278.0	264.	.12
20	TABLE-1	291.5	291.5	0.00	2.	0.0	2361.0	222.	.09
21	TABLE-1	301.4	301.4	0.00	1.	128.2	2441.0	0.	0.00
22	TABLE-1	312.0	312.0	0.00	2.	0.0	2527.0	139.	.06
23	TABLE-1	322.1	322.1	0.00	2.	0.0	2609.0	98.	.04
24	TABLE-1	332.1	332.1	0.00	2.	0.0	2690.0	58.	.02
25	TABLE-1	342.2	342.2	0.00	1.	169.0	2772.0	0.	0.00
26	TABLE-1	352.3	352.3	0.00	2.	3.0	2854.0	0.	0.00
27	TABLE-1	362.7	362.7	0.00	2.	8.2	2938.0	0.	0.00
28	TABLE-1	373.0	373.0	0.00	2.	13.3	3021.0	0.	0.00
29	TABLE-1	382.8	382.8	0.00	2.	18.2	3101.0	0.	0.00
30	TABLE-1	393.2	393.2	0.00	2.	23.4	3185.0	0.	0.00
31	TABLE-1	403.3	403.3	0.00	2.	28.5	3267.0	0.	0.00
32	TABLE-1	413.6	413.6	0.00	2.	33.6	3350.0	0.	0.00
33	TABLE-1	423.6	423.6	0.00	2.	38.6	3431.0	0.	0.00
34	TABLE-1	433.8	433.8	0.00	2.	43.7	3514.0	0.	0.00
35	TABLE-2	280.5	266.5	14.03	2.	0.0	3598.0	422.	.12
36	TABLE-2	286.9	272.6	14.35	1.	113.7	3680.0	0.	0.00
37	TABLE-2	293.3	278.7	14.67	2.	0.0	3762.0	340.	.09
38	TABLE-2	299.6	284.7	14.98	2.	0.0	3843.0	300.	.08
39	TABLE-2	306.0	290.7	15.30	2.	0.0	3924.0	259.	.07
40	TABLE-2	312.6	297.0	15.63	1.	139.4	4009.0	0.	0.00
41	TABLE-2	319.0	303.0	15.95	2.	0.0	4091.0	176.	.04
42	TABLE-2	325.5	309.2	16.27	2.	0.0	4174.0	134.	.03
43	TABLE-2	331.8	315.2	16.59	2.	0.0	4255.0	94.	.02
44	TABLE-2	338.2	321.3	16.91	1.	165.0	4338.0	0.	0.00
45	TABLE-2	344.7	327.5	17.24	2.	0.0	4421.0	11.	.00
46	TABLE-2	351.1	333.6	17.56	2.	2.4	4503.0	0.	0.00
47	TABLE-2	357.9	340.0	17.89	2.	5.7	4590.0	0.	0.00
48	TABLE-2	364.2	346.0	18.21	2.	8.9	4671.0	0.	0.00
49	TABLE-2	370.8	352.2	18.54	2.	12.2	4755.0	0.	0.00
50	TABLE-2	376.9	358.1	18.85	2.	15.3	4834.0	0.	0.00
51	TABLE-2	383.3	364.1	19.17	2.	18.5	4916.0	0.	0.00
52	TABLE-2	389.9	370.4	19.49	2.	21.7	5000.0	0.	0.00
53	TABLE-2	396.4	376.6	19.82	2.	25.0	5084.0	0.	0.00
54	TABLE-2	402.8	382.7	20.14	2.	28.2	5166.0	0.	0.00
55	TABLE-2	409.1	388.7	20.46	2.	31.4	5247.0	0.	0.00

Table 6.2 cont'd

56	TABLE-2	415.5	394.7	20.78	2.	34.6	5329.0	0.	0.00
57	TABLE-2	422.1	401.0	21.10	2.	37.9	5413.0	0.	0.00
58	TABLE-2	428.3	406.9	21.42	2.	41.0	5493.0	0.	0.00
59	TABLE-2	434.9	413.2	21.75	2.	44.3	5578.0	0.	0.00
60	TABLE-2	406.0	385.7	20.30	2.	29.8	5207.0	0.	0.00
MONTHLY AVG.:		306.4	298.6	7.79	2.	25.0	3218.3	112.	.07

OPERATIONS SUMMARY: PROCESS STEP- ASSY AREA

YEAR	PC USED	HOURS SCHEDULED	HOURS UTILIZED	HOURS DOWN	SHIFTS PER DAY	OT HRS PER MAN, PER SHIFT	ACTUAL OUTPUT (UNITS)	SURPLUS CAPACITY: UNITS	FRACTION OF OUTPUT
1		1845.	1845.	0.			14944.	2580.	.17
2		3313.	3313.	0.			26837.	2376.	.09
3		4448.	4420.	28.			38711.	422.	.01
4		3944.	3747.	197.			50581.	1314.	.03
5		4836.	4594.	242.			62022.	0.	0.00

Table 6.3 Production Item Production Profile

PRODUCTION PROFILE: PRODUCTION ITEM- WIDGET1 **STANDARD WIDGET, SINGLE VERSION **

MONTH	USER INPUT PRODUCTION	REJECT AMOUNT	ACTUAL PRODUCTION	INVENTORY: BEG OF MONTH	DEMAND UNITS	GROSS SALES UNITS	LOST SALES UNITS	INVENTORY: END OF MONTH
1	250.	13.	263.	0.	10.	10.	0.	240.
2	264.	14.	278.	240.	30.	30.	0.	474.
3	279.	15.	294.	474.	50.	50.	0.	703.
4	293.	15.	308.	703.	71.	71.	0.	925.
5	308.	16.	324.	925.	91.	91.	0.	1142.
6	322.	17.	339.	1142.	111.	111.	0.	1353.
7	336.	18.	354.	1353.	131.	131.	0.	1558.
8	351.	18.	369.	1558.	151.	151.	0.	1758.
9	365.	19.	384.	1758.	171.	171.	0.	1952.
10	380.	20.	400.	1952.	192.	192.	0.	2140.
11	394.	21.	415.	2140.	212.	212.	0.	2322.
12	408.	21.	429.	2322.	232.	232.	0.	2498.
13	423.	22.	445.	2498.	252.	252.	0.	2669.
14	437.	23.	460.	2669.	272.	272.	0.	2834.
15	452.	24.	476.	2834.	292.	292.	0.	2994.
16	466.	25.	491.	2994.	313.	313.	0.	3147.
17	481.	25.	506.	3147.	333.	333.	0.	3295.
18	495.	26.	521.	3295.	353.	353.	0.	3437.
19	509.	27.	536.	3437.	373.	373.	0.	3573.
20	524.	28.	552.	3573.	393.	393.	0.	3704.
21	538.	28.	566.	3704.	413.	413.	0.	3829.
22	553.	29.	582.	3829.	434.	434.	0.	3948.
23	567.	30.	597.	3948.	454.	454.	0.	4061.
24	581.	31.	612.	4061.	474.	474.	0.	4168.
25	596.	31.	627.	4168.	494.	494.	0.	4270.
26	610.	32.	642.	4270.	514.	514.	0.	4366.
27	625.	33.	658.	4366.	534.	534.	0.	4457.
28	639.	34.	673.	4457.	555.	555.	0.	4541.
29	653.	34.	687.	4541.	575.	575.	0.	4619.
30	668.	35.	703.	4619.	595.	595.	0.	4692.
31	682.	36.	718.	4692.	615.	615.	0.	4759.
32	697.	37.	734.	4759.	635.	635.	0.	4821.
33	711.	37.	748.	4821.	655.	655.	0.	4877.
34	725.	38.	763.	4877.	675.	676.	0.	4926.
35	740.	39.	779.	4926.	696.	696.	0.	4970.
36	754.	40.	794.	4970.	716.	716.	0.	5008.
37	769.	40.	809.	5008.	736.	736.	0.	5041.
38	783.	41.	824.	5041.	756.	756.	0.	5068.
39	797.	42.	839.	5068.	776.	776.	0.	5089.
40	812.	43.	855.	5089.	797.	797.	0.	5104.

Table 6.3 cont'd

41	826.	43.	869.	5104.	817.	817.	0.	5113.
42	841.	44.	885.	5113.	837.	837.	0.	5117.
43	855.	45.	900.	5117.	857.	857.	0.	5115.
44	869.	46.	915.	5115.	877.	877.	0.	5107.
45	884.	47.	931.	5107.	897.	897.	0.	5094.
46	898.	47.	945.	5094.	918.	918.	0.	5074.
47	913.	48.	961.	5074.	938.	938.	0.	5049.
48	927.	49.	976.	5049.	958.	958.	0.	5018.
49	942.	50.	992.	5018.	978.	978.	0.	4982.
50	956.	50.	1006.	4982.	998.	998.	0.	4940.
51	970.	51.	1021.	4940.	1018.	1018.	0.	4892.
52	985.	52.	1037.	4892.	1039.	1039.	0.	4838.
53	999.	53.	1052.	4838.	1059.	1059.	0.	4778.
54	1014.	53.	1067.	4778.	1079.	1079.	0.	4713.
55	1028.	54.	1082.	4713.	1099.	1099.	0.	4642.
56	1042.	55.	1097.	4642.	1119.	1119.	0.	4565.
57	1057.	56.	1113.	4565.	1139.	1139.	0.	4483.
58	1071.	56.	1127.	4483.	1160.	1160.	0.	4394.
59	1086.	57.	1143.	4394.	1180.	1180.	0.	4300.
60	1000.	53.	1053.	4300.	1200.	1200.	0.	4100.

PRODUCTION SUMMARY: PRODUCTION ITEM- WIDGET1 **STANDARD WIDGET, SINGLE VERSION **

YEAR	USER INPUT PRODUCTION	REJECT AMOUNT	ACTUAL PRODUCTION	INVENTORY: BEG OF MONTH	DEMAND UNITS	GROSS SALES UNITS	LOST SALES UNITS	INVENTORY: END OF MONTH
1	3950.	207.	4157.		1452.	1452.	0.	
2	6026.	318.	6344.		4356.	4356.	0.	
3	8100.	426.	8526.		7260.	7260.	0.	
4	10174.	535.	10709.		10164.	10164.	0.	
5	12150.	640.	12790.		13068.	13068.	0.	

Table 6.4 Raw Materials Profile

RAW MATERIALS PROFILE: RAW MATERIAL- PINE WOOD **GEORGIA YELLOW PINE

MONTH	AMOUNT REQUIRED	INVENTORY: BEG OF MONTH	AMOUNT RECEIVED	INVENTORY: END OF MONTH	AMOUNT NEW ORDERS
STARTUP PERIOD					0.00
1	14064.00	0.00	14064.00	0.00	14064.00
2	15566.50	0.00	15566.50	0.00	15566.50
3	17159.50	0.00	17159.50	0.00	17159.50
4	18628.00	0.00	18628.00	0.00	18628.00
5	20199.50	0.00	20199.50	0.00	20199.50
6	21702.00	0.00	21702.00	0.00	21702.00
7	23222.00	0.00	23222.00	0.00	23222.00
8	24741.00	0.00	24741.00	0.00	24741.00
9	26301.00	0.00	26301.00	0.00	26301.00
10	27838.50	0.00	27838.50	0.00	27838.50
11	29358.50	0.00	29358.50	0.00	29358.50
12	30843.50	0.00	30843.50	0.00	30843.50
13	32397.50	0.00	32397.50	0.00	32397.50
14	33901.00	0.00	33901.00	0.00	33901.00
15	35471.50	0.00	35471.50	0.00	35471.50
16	37053.00	0.00	37053.00	0.00	37053.00
17	38573.00	0.00	38573.00	0.00	38573.00
18	40076.50	0.00	40076.50	0.00	40076.50
19	41613.00	0.00	41613.00	0.00	41613.00
20	43149.50	0.00	43149.50	0.00	43149.50
21	44635.50	0.00	44635.50	0.00	44635.50
22	46228.50	0.00	46228.50	0.00	46228.50
23	47748.50	0.00	47748.50	0.00	47748.50
24	49251.00	0.00	49251.00	0.00	49251.00
25	50771.00	0.00	50771.00	0.00	50771.00
26	52291.00	0.00	52291.00	0.00	52291.00
27	53845.00	0.00	53845.00	0.00	53845.00
28	55387.50	0.00	55387.50	0.00	55387.50
29	56873.50	0.00	56873.50	0.00	56873.50
30	58427.50	0.00	58427.50	0.00	58427.50
31	59947.50	0.00	59947.50	0.00	59947.50
32	61484.00	0.00	61484.00	0.00	61484.00
33	62986.50	0.00	62986.50	0.00	62986.50
34	64529.00	0.00	64529.00	0.00	64529.00
35	66083.00	0.00	66083.00	0.00	66083.00
36	67602.00	0.00	67602.00	0.00	67602.00
37	69122.00	0.00	69122.00	0.00	69122.00
38	70625.50	0.00	70625.50	0.00	70625.50
39	72128.00	0.00	72128.00	0.00	72128.00
40	73699.50	0.00	73699.50	0.00	73699.50
41	75224.50	0.00	75224.50	0.00	75224.50
42	76762.00	0.00	76762.00	0.00	76762.00
43	78264.50	0.00	78264.50	0.00	78264.50
44	79801.00	0.00	79801.00	0.00	79801.00
45	81338.50	0.00	81338.50	0.00	81338.50
46	82862.50	0.00	82862.50	0.00	82862.50
47	84474.00	0.00	84474.00	0.00	84474.00
48	85976.50	0.00	85976.50	0.00	85976.50
49	87530.50	0.00	87530.50	0.00	87530.50
50	88999.00	0.00	88999.00	0.00	88999.00
51	90519.00	0.00	90519.00	0.00	90519.00
52	92073.00	0.00	92073.00	0.00	92073.00
53	93632.00	0.00	93632.00	0.00	93632.00
54	95152.00	0.00	95152.00	0.00	95152.00
55	96654.50	0.00	96654.50	0.00	96654.50

Table 6.4 cont'd

56	98174.50	0.00	98174.50	0.00	98174.50
57	99728.50	0.00	99728.50	0.00	99728.50
58	101215.50	0.00	101215.50	0.00	101215.50
59	102791.00	0.00	102791.00	0.00	102791.00
60	96025.50	0.00	96025.50	0.00	96025.50

RAW MATERIALS SUMMARY: RAW MATERIAL- PINE WOOD **GEORGIA YELLOW PINE

YEAR	AMOUNT REQUIRED	INVENTORY: BEG OF MONTH	AMOUNT RECEIVED	INVENTORY: END OF MONTH	AMOUNT NEW ORDERS
1	269624.		269624.		269624.
2	490099.		490099.		490099.
3	710228.		710228.		710228.
4	930279.		930279.		930279.
5	1142495.		1142495.		1142495.

Table 6.5 Finished Goods Sales Profile

SALES PROFILE

	1 WIDGET1		2 WIDGET2		3		4		5		TOTAL	
MONTH	GROSS SALES ($100)	LOST SALES ($100)	GROSS SALES ($100)	LOST SALES ($100)	GROSS SALES ($100)	LOST SALES ($100)	GROSS SALES ($100)	LOST SALES ($100)	GROSS SALES ($100)	LOST SALES ($100)	GROSS SALES ($100)	LOST SALES ($100)
1	7.50	0.00	110.00	110.00	0.00	0.00	0.00	0.00	0.00	0.00	117.50	110.00
2	22.50	0.00	134.20	106.70	0.00	0.00	0.00	0.00	0.00	0.00	156.70	106.70
3	37.50	0.00	158.40	102.30	0.00	0.00	0.00	0.00	0.00	0.00	195.90	102.30
4	53.25	0.00	182.60	99.00	0.00	0.00	0.00	0.00	0.00	0.00	235.85	99.00
5	68.25	0.00	206.80	95.70	0.00	0.00	0.00	0.00	0.00	0.00	275.05	95.70
6	83.25	0.00	231.00	91.30	0.00	0.00	0.00	0.00	0.00	0.00	314.25	91.30
7	98.25	0.00	255.20	88.00	0.00	0.00	0.00	0.00	0.00	0.00	353.45	88.00
8	113.25	0.00	279.40	84.70	0.00	0.00	0.00	0.00	0.00	0.00	392.65	84.70
9	128.25	0.00	303.60	80.30	0.00	0.00	0.00	0.00	0.00	0.00	431.85	80.30
10	144.00	0.00	327.80	77.00	0.00	0.00	0.00	0.00	0.00	0.00	471.80	77.00
11	159.00	0.00	352.00	72.60	0.00	0.00	0.00	0.00	0.00	0.00	511.00	72.60
12	174.00	0.00	376.20	69.30	0.00	0.00	0.00	0.00	0.00	0.00	550.20	69.30
13	189.00	0.00	400.40	66.00	0.00	0.00	0.00	0.00	0.00	0.00	589.40	66.00
14	204.00	0.00	424.60	61.60	0.00	0.00	0.00	0.00	0.00	0.00	628.60	61.60
15	219.00	0.00	448.80	58.30	0.00	0.00	0.00	0.00	0.00	0.00	667.80	58.30
16	234.75	0.00	474.10	53.90	0.00	0.00	0.00	0.00	0.00	0.00	708.85	53.90
17	249.75	0.00	498.30	49.50	0.00	0.00	0.00	0.00	0.00	0.00	748.05	49.50
18	264.75	0.00	522.50	46.20	0.00	0.00	0.00	0.00	0.00	0.00	787.25	46.20
19	279.75	0.00	546.70	42.90	0.00	0.00	0.00	0.00	0.00	0.00	826.45	42.90
20	294.75	0.00	570.90	38.50	0.00	0.00	0.00	0.00	0.00	0.00	865.65	38.50
21	309.75	0.00	595.10	35.20	0.00	0.00	0.00	0.00	0.00	0.00	904.85	35.20
22	325.50	0.00	619.30	31.90	0.00	0.00	0.00	0.00	0.00	0.00	944.80	31.90
23	340.50	0.00	643.50	27.50	0.00	0.00	0.00	0.00	0.00	0.00	984.00	27.50
24	355.50	0.00	667.70	24.20	0.00	0.00	0.00	0.00	0.00	0.00	1023.20	24.20
25	370.50	0.00	691.90	19.80	0.00	0.00	0.00	0.00	0.00	0.00	1062.40	19.80
26	385.50	0.00	716.10	16.50	0.00	0.00	0.00	0.00	0.00	0.00	1101.60	16.50
27	400.50	0.00	740.30	13.20	0.00	0.00	0.00	0.00	0.00	0.00	1140.80	13.20
28	416.25	0.00	764.50	8.80	0.00	0.00	0.00	0.00	0.00	0.00	1180.75	8.80
29	431.25	0.00	788.70	5.50	0.00	0.00	0.00	0.00	0.00	0.00	1219.95	5.50
30	446.25	0.00	812.90	2.20	0.00	0.00	0.00	0.00	0.00	0.00	1259.15	2.20
31	461.25	0.00	834.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1296.15	0.00
32	476.25	0.00	855.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1332.05	0.00
33	491.25	0.00	876.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1367.95	0.00
34	507.00	0.00	896.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1403.50	0.00
35	522.00	0.00	917.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1439.40	0.00
36	537.00	0.00	938.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1475.30	0.00
37	552.00	0.00	958.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1510.10	0.00
38	567.00	0.00	979.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1546.00	0.00
39	582.00	0.00	998.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1580.80	0.00

Table 6.5 cont'd

40	597.75	0.00	1019.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1617.45	0.00
41	612.75	0.00	1040.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1653.35	0.00
42	627.75	0.00	1060.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1688.15	0.00
43	642.75	0.00	1081.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1724.05	0.00
44	657.75	0.00	1102.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1759.95	0.00
45	672.75	0.00	1122.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1794.75	0.00
46	688.50	0.00	1142.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1831.40	0.00
47	703.50	0.00	1163.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1867.30	0.00
48	718.50	0.00	1183.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1902.10	0.00
49	733.50	0.00	1204.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1938.00	0.00
50	748.50	0.00	1225.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1973.90	0.00
51	763.50	0.00	1245.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2008.70	0.00
52	779.25	0.00	1266.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2045.35	0.00
53	794.25	0.00	1285.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2080.15	0.00
54	809.25	0.00	1306.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2116.05	0.00
55	824.25	0.00	1327.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2151.95	0.00
56	839.25	0.00	1347.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2186.75	0.00
57	854.25	0.00	1368.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2222.65	0.00
58	870.00	0.00	1389.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2259.30	0.00
59	885.00	0.00	1409.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2294.10	0.00
60	900.00	0.00	1430.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2330.00	0.00

SALES SUMMARY

	1		2		3		4		5			
	WIDGET1		WIDGET2								TOTAL	
YEAR	GROSS SALES ($100)	LOST SALES ($100)	GROSS SALES ($100)	LOST SALES ($100)	GROSS SALES ($100)	LOST SALES ($100)	GROSS SALES ($100)	LOST SALES ($100)	GROSS SALES ($100)	LOST SALES ($100)	GROSS SALES ($100)	LOST SALES ($100)
1	1089.	0.	2917.	1077.	0.	0.	0.	0.	0.	0.	4006.	1077.
2	3267.	0.	6412.	536.	0.	0.	0.	0.	0.	0.	9679.	536.
3	5445.	0.	9834.	66.	0.	0.	0.	0.	0.	0.	15279.	66.
4	7623.	0.	12852.	0.	0.	0.	0.	0.	0.	0.	20475.	0.
5	9801.	0.	15806.	0.	0.	0.	0.	0.	0.	0.	25607.	0.

Table 6.6 Process Step Employment Profile

EMPLOYMENT PROFILE: PROCESS STEP- ASSY AREA

	1 LABOR		2 OPERATOR		3 CRAFTSMAN		4		5		6		TOTAL	
MONTH	NUMBER EMPL'D	TOTAL OT HRS	NUMBER EMPL'D	TOTAL OT HRS	NUMBER EMPL'D	TOTAL OT HRS	NUMBER EMPL'D	TOTAL OT HRS	NUMBER EMPL'D	TOTAL OT HRS	NUMBER EMPL'D	TOTAL OT HRS	NUMBER EMPL'D	TOTAL OT HRS
1	6.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	7.	0.
2	6.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	7.	0.
3	6.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	7.	0.
4	6.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	7.	0.
5	6.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	7.	0.
6	6.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	7.	0.
7	6.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	7.	0.
8	6.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	7.	0.
9	6.	36.	0.	0.	1.	6.	0.	0.	0.	0.	0.	0.	7.	42.
10	6.	98.	0.	0.	1.	16.	0.	0.	0.	0.	0.	0.	7.	114.
11	6.	159.	0.	0.	1.	26.	0.	0.	0.	0.	0.	0.	7.	185.
12	6.	218.	0.	0.	1.	36.	0.	0.	0.	0.	0.	0.	7.	254.
13	6.	280.	0.	0.	1.	47.	0.	0.	0.	0.	0.	0.	7.	327.
14	12.	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	14.	0.
15	12.	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	14.	0.
16	12.	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	14.	0.
17	6.	527.	0.	0.	1.	88.	0.	0.	0.	0.	0.	0.	7.	615.
18	12.	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	14.	0.
19	12.	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	14.	0.
20	12.	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	14.	0.
21	6.	769.	0.	0.	1.	128.	0.	0.	0.	0.	0.	0.	7.	897.
22	12.	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	14.	0.
23	12.	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	14.	0.
24	12.	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	14.	0.
25	6.	1014.	0.	0.	1.	169.	0.	0.	0.	0.	0.	0.	7.	1183.
26	12.	36.	0.	0.	2.	6.	0.	0.	0.	0.	0.	0.	14.	42.
27	12.	98.	0.	0.	2.	16.	0.	0.	0.	0.	0.	0.	14.	114.
28	12.	159.	0.	0.	2.	27.	0.	0.	0.	0.	0.	0.	14.	186.
29	12.	219.	0.	0.	2.	36.	0.	0.	0.	0.	0.	0.	14.	255.
30	12.	281.	0.	0.	2.	47.	0.	0.	0.	0.	0.	0.	14.	328.
31	12.	342.	0.	0.	2.	57.	0.	0.	0.	0.	0.	0.	14.	399.
32	12.	403.	0.	0.	2.	67.	0.	0.	0.	0.	0.	0.	14.	470.
33	12.	463.	0.	0.	2.	77.	0.	0.	0.	0.	0.	0.	14.	540.
34	12.	525.	0.	0.	2.	87.	0.	0.	0.	0.	0.	0.	14.	612.
35	6.	0.	2.	0.	2.	0.	0.	0.	0.	0.	0.	0.	10.	0.
36	3.	341.	1.	114.	1.	114.	0.	0.	0.	0.	0.	0.	5.	569.
37	6.	0.	2.	0.	2.	0.	0.	0.	0.	0.	0.	0.	10.	0.
38	6.	0.	2.	0.	2.	0.	0.	0.	0.	0.	0.	0.	10.	0.
39	6.	0.	2.	0.	2.	0.	0.	0.	0.	0.	0.	0.	10.	0.

Table 6.7 Comprehensive Employment Profile

EMPLOYMENT PROFILE: *COMPREHENSIVE*

MONTH	1 LABOR NUMBER EMPL'D	1 LABOR TOTAL OT HRS	2 OPERATOR NUMBER EMPL'D	2 OPERATOR TOTAL OT HRS	3 CRAFTSMAN NUMBER EMPL'D	3 CRAFTSMAN TOTAL OT HRS	4 NUMBER EMPL'D	4 TOTAL OT HRS	5 NUMBER EMPL'D	5 TOTAL OT HRS	6 NUMBER EMPL'D	6 TOTAL OT HRS	TOTAL NUMBER EMPL'D	TOTAL TOTAL OT HRS
1	9.	0.	1.	0.	2.	0.	0.	0.	0.	0.	0.	0.	12.	0.
2	9.	0.	1.	0.	2.	0.	0.	0.	0.	0.	0.	0.	12.	0.
3	9.	0.	1.	0.	2.	0.	0.	0.	0.	0.	0.	0.	12.	0.
4	9.	0.	1.	0.	2.	0.	0.	0.	0.	0.	0.	0.	12.	0.
5	9.	0.	1.	0.	2.	0.	0.	0.	0.	0.	0.	0.	12.	0.
6	9.	0.	1.	0.	2.	0.	0.	0.	0.	0.	0.	0.	12.	0.
7	9.	0.	1.	0.	2.	0.	0.	0.	0.	0.	0.	0.	12.	0.
8	9.	0.	1.	0.	2.	0.	0.	0.	0.	0.	0.	0.	12.	0.
9	9.	36.	1.	0.	2.	6.	0.	0.	0.	0.	0.	0.	12.	42.
10	9.	98.	1.	0.	2.	16.	0.	0.	0.	0.	0.	0.	12.	114.
11	9.	159.	1.	0.	2.	26.	0.	0.	0.	0.	0.	0.	12.	185.
12	9.	218.	1.	0.	2.	36.	0.	0.	0.	0.	0.	0.	12.	254.
13	9.	280.	1.	0.	2.	47.	0.	0.	0.	0.	0.	0.	12.	327.
14	15.	0.	1.	0.	3.	0.	0.	0.	0.	0.	0.	0.	19.	0.
15	15.	0.	1.	0.	3.	0.	0.	0.	0.	0.	0.	0.	19.	0.
16	15.	0.	1.	0.	3.	0.	0.	0.	0.	0.	0.	0.	19.	0.
17	9.	527.	1.	0.	2.	88.	0.	0.	0.	0.	0.	0.	12.	615.
18	15.	0.	1.	0.	3.	0.	0.	0.	0.	0.	0.	0.	19.	0.
19	15.	0.	1.	0.	3.	0.	0.	0.	0.	0.	0.	0.	19.	0.
20	15.	0.	1.	0.	3.	0.	0.	0.	0.	0.	0.	0.	19.	0.
21	9.	769.	1.	0.	2.	128.	0.	0.	0.	0.	0.	0.	12.	897.
22	15.	0.	1.	0.	3.	0.	0.	0.	0.	0.	0.	0.	19.	0.
23	15.	0.	1.	0.	3.	0.	0.	0.	0.	0.	0.	0.	19.	0.
24	15.	0.	1.	0.	3.	0.	0.	0.	0.	0.	0.	0.	19.	0.
25	9.	1014.	1.	0.	2.	169.	0.	0.	0.	0.	0.	0.	12.	1183.
26	15.	36.	1.	0.	3.	6.	0.	0.	0.	0.	0.	0.	19.	42.
27	15.	98.	1.	0.	3.	16.	0.	0.	0.	0.	0.	0.	19.	114.
28	15.	159.	1.	0.	3.	27.	0.	0.	0.	0.	0.	0.	19.	186.
29	15.	219.	1.	0.	3.	36.	0.	0.	0.	0.	0.	0.	19.	255.
30	15.	281.	1.	0.	3.	47.	0.	0.	0.	0.	0.	0.	19.	328.
31	15.	342.	1.	0.	3.	57.	0.	0.	0.	0.	0.	0.	19.	399.
32	15.	403.	1.	0.	3.	67.	0.	0.	0.	0.	0.	0.	19.	470.
33	15.	463.	1.	0.	3.	77.	0.	0.	0.	0.	0.	0.	19.	540.
34	15.	525.	1.	0.	3.	87.	0.	0.	0.	0.	0.	0.	19.	612.
35	9.	0.	3.	0.	3.	0.	0.	0.	0.	0.	0.	0.	15.	0.
36	6.	341.	2.	114.	2.	114.	0.	0.	0.	0.	0.	0.	10.	569.
37	9.	0.	3.	0.	3.	0.	0.	0.	0.	0.	0.	0.	15.	0.
38	9.	0.	3.	0.	3.	0.	0.	0.	0.	0.	0.	0.	15.	0.
39	9.	0.	3.	0.	3.	0.	0.	0.	0.	0.	0.	0.	15.	0.

Table 6.8 Capital Expansion Profile

CAPITAL EXPANSION PROFILE

PROCESS CONFIGURATION	USED IN PROCESS STEP:	MONTH ORDERED	MONTH RECEIVED	MONTH READY	PERIOD EXPENSE	DEPRECIABLE COST	TOTAL INVESTMENT
TABLE-2	FIN AREA	-4.	0.	1.	50.00	300.00	350.00
TABLE-1	ASSY AREA	0.	1.	1.	25.00	100.00	125.00
TABLE-2	ASSY AREA	30.	34.	35.	50.00	300.00	350.00
****TOTAL****	>>>	>>>	>>>	>>>	125.	700.	825.

Table 6.9 Energy/Utility Usage Profile

ENERGY/UTILITY USAGE PROFILE

MONTH	1 GAS CONSUMPTION (CUBIC FEET)	COST ($)	2 ELEC/220 CONSUMPTION (KWH)	COST ($)	3 CONSUMPTION ( )	COST ($)	4 CONSUMPTION ( )	COST ($)	TOTAL COST ($)
1	0.00	0.00	1.44	.32	0.00	0.00	0.00	0.00	.32
2	0.00	0.00	1.60	.36	0.00	0.00	0.00	0.00	.36
3	0.00	0.00	1.76	.40	0.00	0.00	0.00	0.00	.40
4	0.00	0.00	1.92	.43	0.00	0.00	0.00	0.00	.43
5	0.00	0.00	2.08	.47	0.00	0.00	0.00	0.00	.47
6	0.00	0.00	2.24	.50	0.00	0.00	0.00	0.00	.50
7	0.00	0.00	2.40	.54	0.00	0.00	0.00	0.00	.54
8	0.00	0.00	2.55	.57	0.00	0.00	0.00	0.00	.57
9	0.00	0.00	2.72	.61	0.00	0.00	0.00	0.00	.61
10	0.00	0.00	2.88	.65	0.00	0.00	0.00	0.00	.65
11	0.00	0.00	3.03	.68	0.00	0.00	0.00	0.00	.68
12	0.00	0.00	3.19	.72	0.00	0.00	0.00	0.00	.72
13	0.00	0.00	3.35	.75	0.00	0.00	0.00	0.00	.75
14	0.00	0.00	3.51	.79	0.00	0.00	0.00	0.00	.79
15	0.00	0.00	3.67	.83	0.00	0.00	0.00	0.00	.83
16	0.00	0.00	3.84	.86	0.00	0.00	0.00	0.00	.86
17	0.00	0.00	3.99	.90	0.00	0.00	0.00	0.00	.90
18	0.00	0.00	4.15	.93	0.00	0.00	0.00	0.00	.93
19	0.00	0.00	4.31	.97	0.00	0.00	0.00	0.00	.97
20	0.00	0.00	4.47	1.01	0.00	0.00	0.00	0.00	1.01
21	0.00	0.00	4.63	1.04	0.00	0.00	0.00	0.00	1.04
22	0.00	0.00	4.79	1.08	0.00	0.00	0.00	0.00	1.08
23	0.00	0.00	4.95	1.11	0.00	0.00	0.00	0.00	1.11
24	0.00	0.00	5.11	1.15	0.00	0.00	0.00	0.00	1.15
25	0.00	0.00	5.26	1.18	0.00	0.00	0.00	0.00	1.18
26	0.00	0.00	5.42	1.22	0.00	0.00	0.00	0.00	1.22
27	0.00	0.00	5.58	1.26	0.00	0.00	0.00	0.00	1.26
28	0.00	0.00	5.75	1.29	0.00	0.00	0.00	0.00	1.29
29	0.00	0.00	5.90	1.33	0.00	0.00	0.00	0.00	1.33
30	0.00	0.00	6.06	1.36	0.00	0.00	0.00	0.00	1.36
31	0.00	0.00	6.22	1.40	0.00	0.00	0.00	0.00	1.40
32	0.00	0.00	6.38	1.44	0.00	0.00	0.00	0.00	1.44
33	0.00	0.00	6.53	1.47	0.00	0.00	0.00	0.00	1.47
34	0.00	0.00	6.70	1.51	0.00	0.00	0.00	0.00	1.51
35	0.00	0.00	20.18	4.54	0.00	0.00	0.00	0.00	4.54
36	0.00	0.00	20.65	4.65	0.00	0.00	0.00	0.00	4.65
37	0.00	0.00	21.11	4.75	0.00	0.00	0.00	0.00	4.75
38	0.00	0.00	21.57	4.85	0.00	0.00	0.00	0.00	4.85
39	0.00	0.00	22.02	4.96	0.00	0.00	0.00	0.00	4.96

Table 6.9 cont'd

40	0.00	0.00	22.50	5.06	0.00	0.00	0.00	0.00	5.06
41	0.00	0.00	22.96	5.17	0.00	0.00	0.00	0.00	5.17
42	0.00	0.00	23.43	5.27	0.00	0.00	0.00	0.00	5.27
43	0.00	0.00	23.89	5.37	0.00	0.00	0.00	0.00	5.37
44	0.00	0.00	24.35	5.48	0.00	0.00	0.00	0.00	5.48
45	0.00	0.00	24.82	5.59	0.00	0.00	0.00	0.00	5.59
46	0.00	0.00	25.28	5.69	0.00	0.00	0.00	0.00	5.69
47	0.00	0.00	25.77	5.80	0.00	0.00	0.00	0.00	5.80
48	0.00	0.00	26.23	5.90	0.00	0.00	0.00	0.00	5.90
49	0.00	0.00	26.70	6.01	0.00	0.00	0.00	0.00	6.01
50	0.00	0.00	27.15	6.11	0.00	0.00	0.00	0.00	6.11
51	0.00	0.00	27.61	6.21	0.00	0.00	0.00	0.00	6.21
52	0.00	0.00	28.09	6.32	0.00	0.00	0.00	0.00	6.32
53	0.00	0.00	28.56	6.43	0.00	0.00	0.00	0.00	6.43
54	0.00	0.00	29.02	6.53	0.00	0.00	0.00	0.00	6.53
55	0.00	0.00	29.48	6.63	0.00	0.00	0.00	0.00	6.63
56	0.00	0.00	29.94	6.74	0.00	0.00	0.00	0.00	6.74
57	0.00	0.00	30.41	6.84	0.00	0.00	0.00	0.00	6.84
58	0.00	0.00	30.86	6.94	0.00	0.00	0.00	0.00	6.94
59	0.00	0.00	31.34	7.05	0.00	0.00	0.00	0.00	7.05
60	0.00	0.00	29.27	6.58	0.00	0.00	0.00	0.00	6.58

ENERGY/UTILITY USAGE SUMMARY

	1		2		3		4		
	GAS		ELEC/220						
YEAR	CONSUMPTION (CUBIC FEET)	COST ($)	CONSUMPTION (KVH)	COST ($)	CONSUMPTION ( )	COST ($)	CONSUMPTION ( )	COST ($)	TOTAL COST ($)
1	0.	0.	28.	6.	0.	0.	0.	0.	6.
2	0.	0.	51.	11.	0.	0.	0.	0.	11.
3	0.	0.	101.	23.	0.	0.	0.	0.	23.
4	0.	0.	284.	64.	0.	0.	0.	0.	64.
5	0.	0.	348.	78.	0.	0.	0.	0.	78.

higher output rate. Note that the number of shifts does not drop until the following month. Analysis of the data shows that the reason for expansion was that the maximum number of months of operation above long-run overtime levels for TABLE-1 had been reached. Despite the greater capacity of TABLE-2, use of only one shift would have required another month at high levels of overtime; which was not permissible. The cyclical pattern of workforce adjustments in months 36-39 and 40-43 stems from the following sequence:

1) A decrease in one shift which eliminates surplus capacity, but causes high levels of overtime.
2) After one month at high overtime, another shift is added. This causes excess capacity, but no layoffs can occur for at least 3 months due to minimum workforce contraction period restriction.

After month 43, the load on process step ASSY AREA is sufficient to justify two shifts.

6.3.2 Financial Reporting

Financial reporting consists of monthly cash flow and quarterly income statements with annual summaries of both. Sample reports for the Widget model are shown in Tables 6.10 through 6.13.

Upon request, MVPM will calculate the present worth of the monthly net cash flow, at a user-specified discount rate. Additionally, it examines the sensitivity of this index to variations in discount rate by calculating ten other cash flow present worth values over a range of $\pm$ 50% of the value specified by the user (Table 6.14).

Table 6.15 shows an example of the ratio analyses which can be

Table 6.10 Monthly Cash Flow Report

CASH FLOW REPORT FOR YEAR 1	MONTH: 1 ($100)	MONTH: 2 ($100)	MONTH: 6 ($100)
CASH BALANCE (BOP)	200.00	10.00	40.87
TOTAL RECEIPTS:			
NET SALES:			
GROSS SALES	0.00	117.50	275.05
RETURNS, ALLOWANCES, BAD DEBT	0.00	70.50	165.03
	0.00	47.00	110.02
SHAREHOLDER EQUITY	0.00	0.00	0.00
BORROWING	0.00	124.77	80.38
SALE OF PLANT EQUIPMENT	0.00	0.00	0.00
TOTAL CASH INFLOW	0.00	171.77	190.40
TOTAL DISBURSEMENTS:			
PLANT WAGES AND SALARIES:			
REGULAR TIME	87.47	87.47	87.47
OVER TIME	0.00	0.00	0.00
LABOR HIRE/FIRE COSTS	21.87	0.00	0.00
RAW MATERIALS PURCHASES	0.00	41.60	59.49
PLANT EQUIPMENT PURCHASES	4.75	0.00	0.00
PLANT RENT	8.40	8.40	8.40
PLANT OVERHEAD	.64	.71	.98
PLANT ENERGY/UTILITY COSTS	.00	.00	.01
PAYROLL TAXES AND FRINGE BENEFITS	4.37	4.37	4.37
INVENTORY TAX	0.00	0.00	0.00
PLANT EQUIPMENT TAX	0.00	0.00	0.00
SALES AND MARKETING EXPENSE	1.00	1.15	1.76
ADMINISTRATIVE SALARIES	4.00	4.19	4.93
OFFICE EQUIPMENT PURCHASES	0.00	10.00	10.00
OTHER ADMINISTRATIVE EXPENSES	1.00	1.02	1.08
INTEREST EXPENSE	.87	1.48	4.58
DEBT REPAYMENT	55.63	0.00	0.00
INCOME TAX PAYMENTS	0.00	0.00	0.00
TOTAL CASH OUTFLOW	190.00	160.38	183.07
NET CASH FLOW	-190.00	11.39	7.34
CASH BALANCE (EOP)	10.00	21.39	48.20
OUTSTANDING DEBT (EOP)	44.37	169.14	523.90

Table 6.11 Annual Cash Flow Report

CASH FLOW REPORT FOR YEAR 1

	($100)
CASH BALANCE (BOP)	200.

TOTAL RECEIPTS:	
NET SALES:	
GROSS SALES	3456.
RETURNS, ALLOWANCES, BAD DEBT	2074.

	1382.
SHAREHOLDER EQUITY	0.
BORROWING	737.
SALE OF PLANT EQUIPMENT	0.

TOTAL CASH INFLOW	2120.

TOTAL DISBURSEMENTS:	
PLANT WAGES AND SALARIES:	
REGULAR TIME	1050.
OVER TIME	48.
LABOR HIRE/FIRE COSTS	22.
RAW MATERIALS PURCHASES	703.
PLANT EQUIPMENT PURCHASES	5.
PLANT RENT	101.
PLANT OVERHEAD	12.
PLANT ENERGY/UTILITY COSTS	0.
PAYROLL TAXES AND FRINGE BENEFITS	55.
INVENTORY TAX	0.
PLANT EQUIPMENT TAX	0.
SALES AND MARKETING EXPENSE	22.
ADMINISTRATIVE SALARIES	60.
OFFICE EQUIPMENT PURCHASES	40.
OTHER ADMINISTRATIVE EXPENSES	13.
INTEREST EXPENSE	53.
DEBT REPAYMENT	56.
INCOME TAX PAYMENTS	5.

TOTAL CASH OUTFLOW	2243.

NET CASH FLOW	-123.
CASH BALANCE (EOP)	77.
	=======
OUTSTANDING DEBT (EOP)	782.

Table 6.12 Quarterly Income Statements

NET INCOME STATEMENT FOR YEAR 1

	QUARTER: 1		QUARTER: 4	
	($100)	($100)	($100)	($100)
NET SALES		188.04		613.20
COST OF GOODS SOLD:				
FINISHED GOODS INVENTORY (BOP)	0.00		566.13	
COST OF GOODS PRODUCED:				
COST OF RAW MATERIALS USED:				
RM INVENTORY (BOP)	0.00		0.00	
RM RECEIVED	138.19		258.54	
RM INVENTORY (EOP)	0.00		0.00	
	138.19		258.54	
PLANT WAGES AND SALARIES	262.40		306.66	
PLANT LABOR HIRE/FIRE COSTS	21.87		0.00	
PLANT EQIPMENT DEPRECIATION	.13		.13	
PLANT RENTAL EXPENSE	25.20		25.20	
PLANT OVERHEAD	2.88		3.95	
PLANT ENERGY/UTILITY COSTS	.01		.02	
PAYROLL TAXES & FRINGE BENEFITS	13.12		15.33	
INVENTORY TAX	0.00		35.57	
EQUIPMENT TAX	0.00		.17	
	463.78		645.57	
FINISHED GOODS INVENTORY (EOP)	281.31	182.47	752.87	458.83
GROSS INCOME		5.57		154.37
SALES AND ADMINISTRATIVE EXPENSE:				
SALES AND MARKETING EXPENSE	3.46		7.58	
ADMINISTRATIVE SALARIES	12.56		17.59	
OFFICE EQUIPMENT DEPRECIATION	.50		2.00	
OTHER ADMINISTRATIVE EXPENSES	3.05	19.57	3.51	30.68
NET OPERATING INCOME		-14.00		123.69
INTEREST EXPENSE		4.67		19.82
NET INCOME BEFORE INCOME TAXES		-18.67		103.87
INCOME TAX EXPENSE		0.00		17.10
NET INCOME AFTER INCOME TAXES		-18.67		86.77

Table 6.13 Annual Income Statement

NET INCOME STATEMENT FOR YEAR 1

	($100)	($100)
NET SALES		1602.
COST OF GOODS SOLD:		
FINISHED GOODS INVENTORY (BOP)	0.	

COST OF GOODS PRODUCED:		
COST OF RAW MATERIALS USED:		
RM INVENTORY (BOP)	0.	
RM RECEIVED	793.	
RM INVENTORY (EOP)	0.	

	793.	
PLANT WAGES AND SALARIES	1097.	
PLANT LABOR HIRE/FIRE COSTS	22.	
PLANT EQIPMENT DEPRECIATION	1.	
PLANT RENTAL EXPENSE	101.	
PLANT OVERHEAD	13.	
PLANT ENERGY/UTILITY COSTS	0.	
PAYROLL TAXES & FRINGE BENEFITS	55.	
INVENTORY TAX	36.	
EQUIPMENT TAX	0.	

	2117.	
FINISHED GOODS INVENTORY (EOP)	753.	1364.
	-------	-------
GROSS INCOME		238.
SALES AND ADMINISTRATIVE EXPENSE:		
SALES AND MARKETING EXPENSE	22.	
ADMINISTRATIVE SALARIES	60.	
OFFICE EQUIPMENT DEPRECIATION	6.	
OTHER ADMINISTRATIVE EXPENSES	13.	101.
	-------	-------
NET OPERATING INCOME		137.
INTEREST EXPENSE		53.

NET INCOME BEFORE INCOME TAXES		84.
INCOME TAX EXPENSE		22.

NET INCOME AFTER INCOME TAXES		62.
		=======
OPERATING LOSS:		
CUMULATIVE		0.

Table 6.14 Discounted Cash Flow Analysis

DISCOUNTED CASH FLOW ANALYSIS

SENSITIVITY TO 50% VARIATION (+-) AROUND INTEREST RATE OF .15

RATE	PRESENT WORTH ($)
.08	282246.79
.09	265908.30
.11	250701.74
.12	236533.91
.14	223320.46
.15	210984.90
.17	199457.85
.18	188676.20
.20	178582.54
.21	169124.58
.23	160254.58

NOTE: FOR DCF ANALYSIS, STARTUP LOAN AND EQUITY AMOUNT ARE TREATED AS POSITIVE AND NEGATIVE COMPONENTS, RESPECTIVELY, OF THE MONTH ONE NET CASH FLOW.

Table 6.15 Financial Ratio Analysis

FINANCIAL RATIO ANALYSIS: YEAR 1

MEASURES OF LIQUIDITY

CURRENT RATIO	QUICK RATIO	FINISHED GOODS INVENTORY: TURNOVER	FINISHED GOODS INVENTORY: AVG. DAYS IN	RAW MATERIALS INVENTORY: TURNOVER	RAW MATERIALS INVENTORY: AVG. DAYS IN
7.44	2.02	3.62	100.70	******	.00

LONG TERM FINANCIAL STRENGTH

DEBT TO EQUITY RATIO	TIMES-INTEREST-EARNED
4.83	2.58

OPERATING EFFICIENCY

OPERATING RATIO
.91

PROFITABILITY

GROSS PROFIT MARGIN	NET PROFIT MARGIN	RETURN ON OWNER EQUITY	RETURN ON TOTAL ASSETS
.15	.04	.38	.06

NOTE: ASTERISKS (******) INDICATE THAT INDEX IS VERY LARGE OR CANNOT BE COMPUTED WITH CURRENT YEAR'S DATA.

generated from each year's annual cash flow and income information the formulae used for computation are shown below.

$$\text{Current Ratio} = \frac{\text{Current Assets}}{\text{Current Liabilities}}$$

$$= \frac{\text{Cash + Accounts + Inventory}}{\text{Accounts Receivable + Taxes Payable}}$$

The Cash and Inventory accounts are equal, respectively, to the cash balance (EOP), and the sum for raw materials and finished goods inventories. Because of assumptions on payment, taxes payable consists of taxes on inventory, equipment, and income that show on the income statement. Accounts receivable are computed as one third of quarterly sales in the last quarterly income statement. Accounts payable are calculated in similar fashion from raw materials purchased in the last quarter. The formula for the quick ratio is the same as that for the current ratio, except that inventories do not appear in the numerator.

$$\text{Finished Goods Inventory Turnover} = \frac{\text{Cost of Goods Sold}}{\text{Finished Goods Inv. (BOP + EOP)/2}}$$

$$\text{Raw Materials Inventory Turnover} = \frac{\text{Cost of Raw Materials Used}}{\text{Raw Materials Inv. (BOP + EOP)/2}}$$

$$\text{Time in Inventory} = \frac{365}{\text{Inventory Turnover}}$$

$$\text{Debt to Equity Ratio} = \frac{\text{Total Debt}}{\text{Total Equity}}$$

$$= \frac{\text{Cumulative Debt}}{\text{Equity Investment + Cumulative Earnings}}$$

In the denominator of the debt to equity ratio, cumulative earnings acts as a proxy for the balance sheet retained earnings account, based on the assumption that no dividends are paid.

$$\text{Times-Interest-Earned} = \frac{\text{Net Operating Income}}{\text{Interest Expense}}$$

$$\text{Operating Efficiency} = \frac{\text{Operating Expenses}}{\text{Operating Revenues}}$$

$$= \frac{\text{Cost of Goods Sold + S\&A Expense}}{\text{Net Sales}}$$

$$\text{Gross Profit Margin} = \frac{\text{Gross Income}}{\text{Net Sales}}$$

$$\text{Net Profit Margin} = \frac{\text{Net Income After Taxes}}{\text{Net Sales}}$$

$$\text{Return on Owner Equity} = \frac{\text{Net Income After Taxes}}{\text{Equity Investment + Cumulative Earnings}}$$

$$\text{Return on Assets} = \frac{\text{Net Income After Taxes}}{\text{Total Assets}}$$

$$= \frac{\text{Net Income After Taxes}}{\text{Total Liabilities}}$$

$$= \frac{\text{Net Income After Taxes}}{\text{Current Liabilities + Owner Equity + Debt}}$$

The indices listed above yield a multi-dimensional view of a firm being studied: short and long term financial strength, operating efficiency, and profitability vis-a-vis different groups with financial interest in the company. While the indices used is by no means exhaustive, they do comprise many of the most commonly used measures.

Figure 6.6 shows the final form of output available: a plot of monthly cash flow. Suitable accuracy is not provided to enable the points plotted to be used as the basis for computation. Rather, the graph produced can serve as a visual reinforcement of numerical data, or as a means for deciding on the extent of reporting desired from any given configuration of input data. Reference to Figure 6.7 illustrates this fact. The steady cash flow in year one is due to constant borrowing to cover net outflow from operations, and to maintain required minimum balances. The pattern for years two and three illustrates the effect of loan repayments as the business begins to become solvent. In years four and five, the business becomes profitable: the sharp negative flows occurring every three months stem from quarterly tax payments in the month after end-of-quarter.

6.4 Equipment Considerations

6.4.1 Transportability

As was stated in Chapter III, MVPM was coded with transportability in mind. The language used was Control Data Corporation (CDC) FORTRAN Extended 4.6, which is designed to comply with the American National Standards Institute FORTRAN. Effort was made to avoid use of language elements peculiar to CDC. While this was largely successful, certain

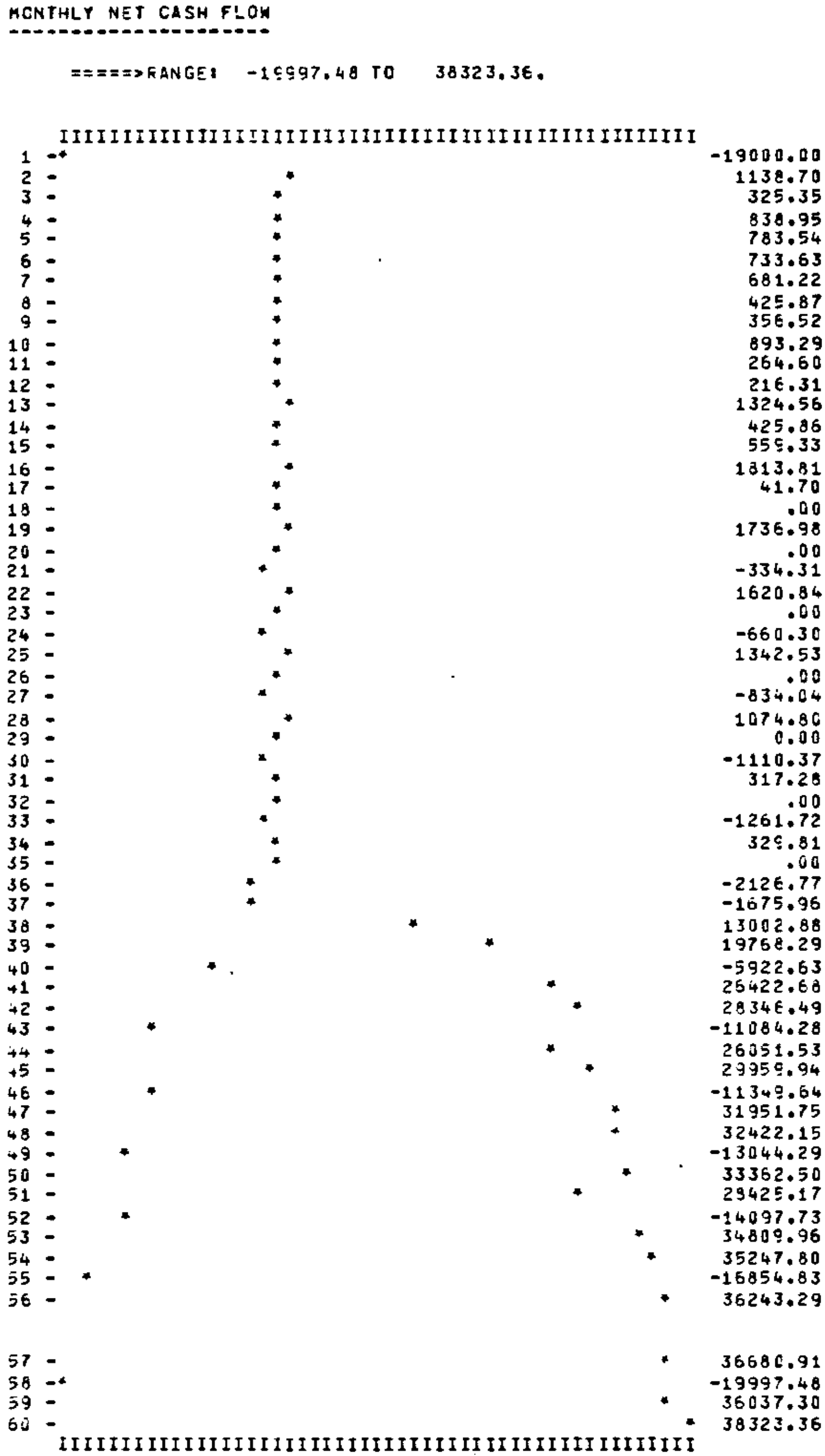


Figure 6.6 Plot of Monthly Net Cash Flow

nonstandard usages were necessary:

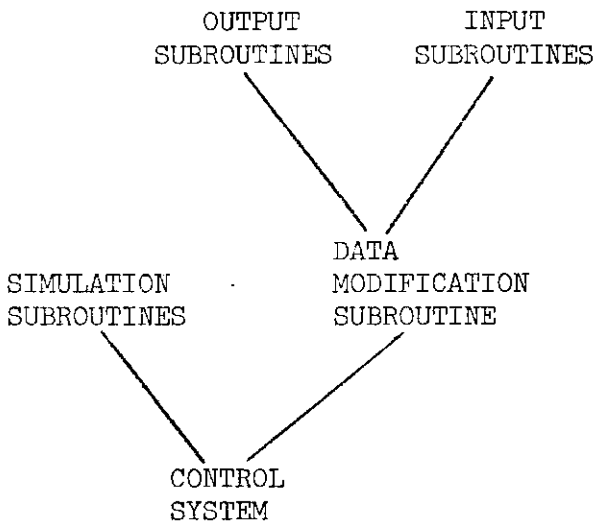
1) The PROGRAM statement. This is mandatory in CDC FORTRAN.
2) The EOF(u) function, where u is a device number. It was necessary to use this in cases where the user could most logically terminate an input sequence with a blank line.
3) Implied DO-Loops in data statements. Used in block data subroutine.

Use of the 60-bit CDC word for character data storage may also cause problems on systems with different word configurations. Taken as a whole, the above items are relatively minor, and fall well within the scope of the "one-time effort" mentioned in Chapter III.

6.4.2 Required Core Space and Speed of Processing

One of the more serious constraints on model construction was that the main program and all external references had to be small enough to allow for interactive processing. MVPM was developed and run on the CDC Cyber 74 as configured at the Georgia Institute of Technology. On this system, large jobs receive low priority, so that there exists a very real tradeoff between size and interactive speed. Hence the use of large arrays was avoided except where necessary.

In this regard, the goal of transportability proved to be a hinderance. If full use were made of CDC loader options, a segmentation scheme could have been developed to greatly reduce core requirements. The program in Appendix C requires $144{,}400_8$ $(51{,}456_{10})$ words of core storage to load. Segmentation of the load could be achieved as illustrated by the tree structure on Page 187.



As this illustration indicates, use of segmentation would keep the large input and output subroutines from being core resident at the same time.

Experience with MVPM (using data presented in the next chapter) has shown that the simulation process takes approximately 6-8 CPU seconds. Report generation is more costly, with a full set of reports requiring as much as 10-14 CPU seconds. These numbers are very reasonable, and use of compiler optimizing options and other system features would probably result in even faster processing.

6.5 Validation

Model validation was implemented along the lines of the equations of Chapter V, and the raw materials ordering algorithms presented earlier in this chapter. For varying input configurations, monthly and annual report data were checked via manual computation. Numerous checks of this nature were made during model development. Any errors discovered in logic or coding were immediately corrected.

One drawback to this procedure is that the problems used for testing had to be of simple enough structure to allow for feasible manual evaluation. A desirable avenue for future work with the model would be to design a means for testing its performance on large nad/or very complex problems.

CHAPTER VII

APPLICATION OF THE MANUFACTURING VENTURE PLANNING MODEL

This chapter describes the applications of MVPM to a new venture proposal. The venture to be examined is a stapler manufacturing firm. The purpose of this use of the model is to illustrate its adaptability to a real case. The data which is the basis for this case was developed by Ricardo Lopez, Guillermo Rodriguez, Nathan Slochowski, and Oscar Velasco while engaged in graduate study at the Georgia Institute of Technology.

The firm will initially produce a single line of staplers, composed of parts as shown in Figure 7.1. The venture plan calls for some parts to be purchased, at least in the initial years of operation. Specifically, the firm will have capacity for conversion of sheet steel: stamping press, feeder, degreasing equipment, and painting equipment. Parts that will be purchased are:

Plastic: stapler base
presser

Tin: catch holder
rivet

Other: spring (steel)
axle (cold rolled steel)
shaft (carbon steel)

Manufacture of parts from sheet steel and assembly of components into finished staplers is to take place in a plant composed of six areas:

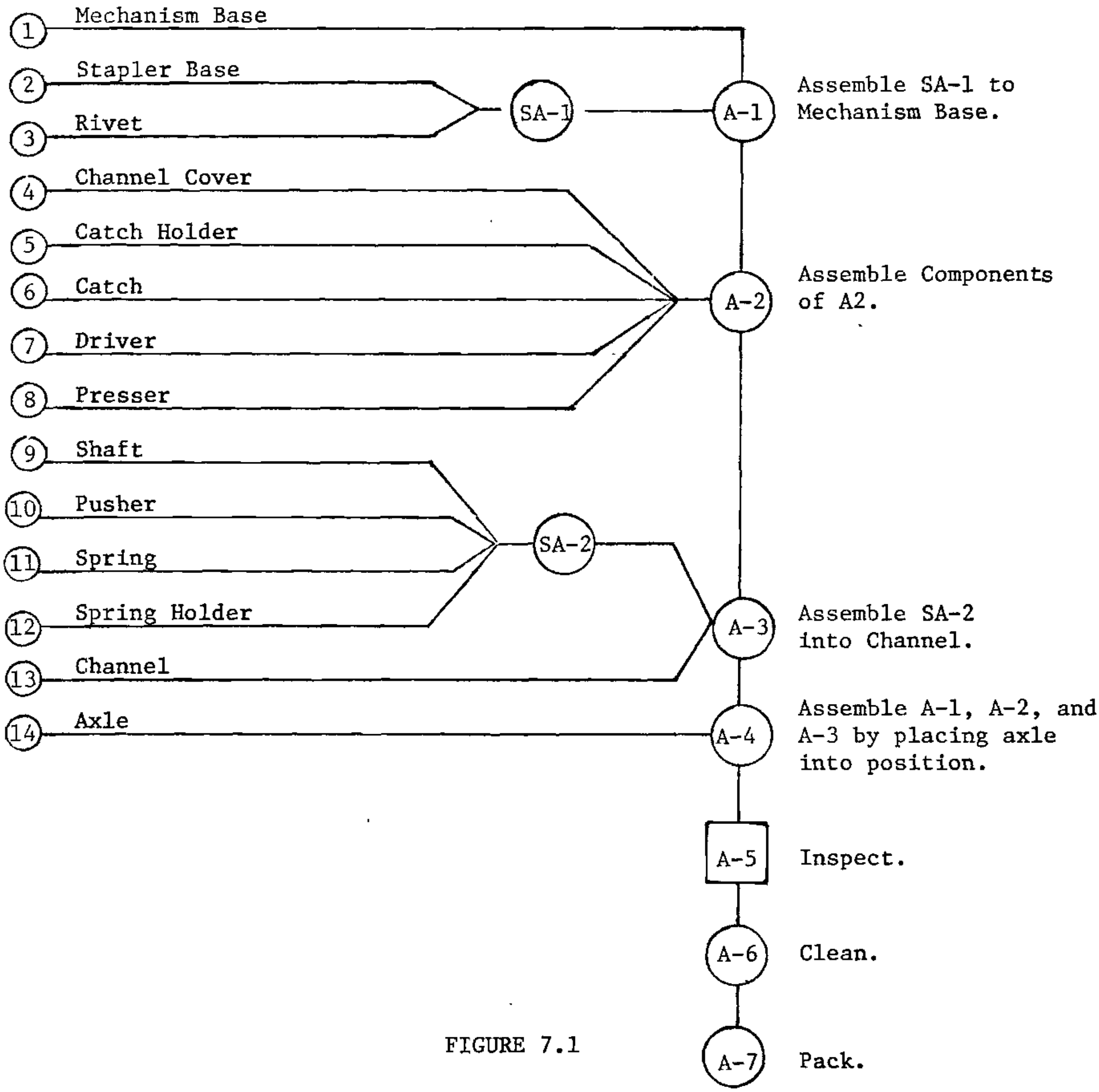


FIGURE 7.1

ASSEMBLY CHART FOR STAPLER

Stamping Area

Degreasing Area

Painting Area

Assembling Area

Finished Product Storage

Raw Materials Storage

The operations necessary for stapler construction are shown in Figure 7.2. As the figure shows, certain parts are manufactured by the firm, and then are sent to an outside contractor for special processing before final assembly takes place.

The venture outline provided above does not fit neatly into the characterization scheme developed in Chapter V. Two main problems exist:

1) Straightforward use of the plant areas described above and the information contained in Fiugre 7.2 for development of process step/production item relations exceeds the bounds on problem size.

2) MVPM does not explicitly provide for use of contractors. Application of the model requires some modification of the manner in which the enterprise and its operations are described. One means of attaining usable results is described below.

The six areas described above are aggregated into four:

Stamping and Degreasing Area

Painting Area

Assembly Area

Storage Area

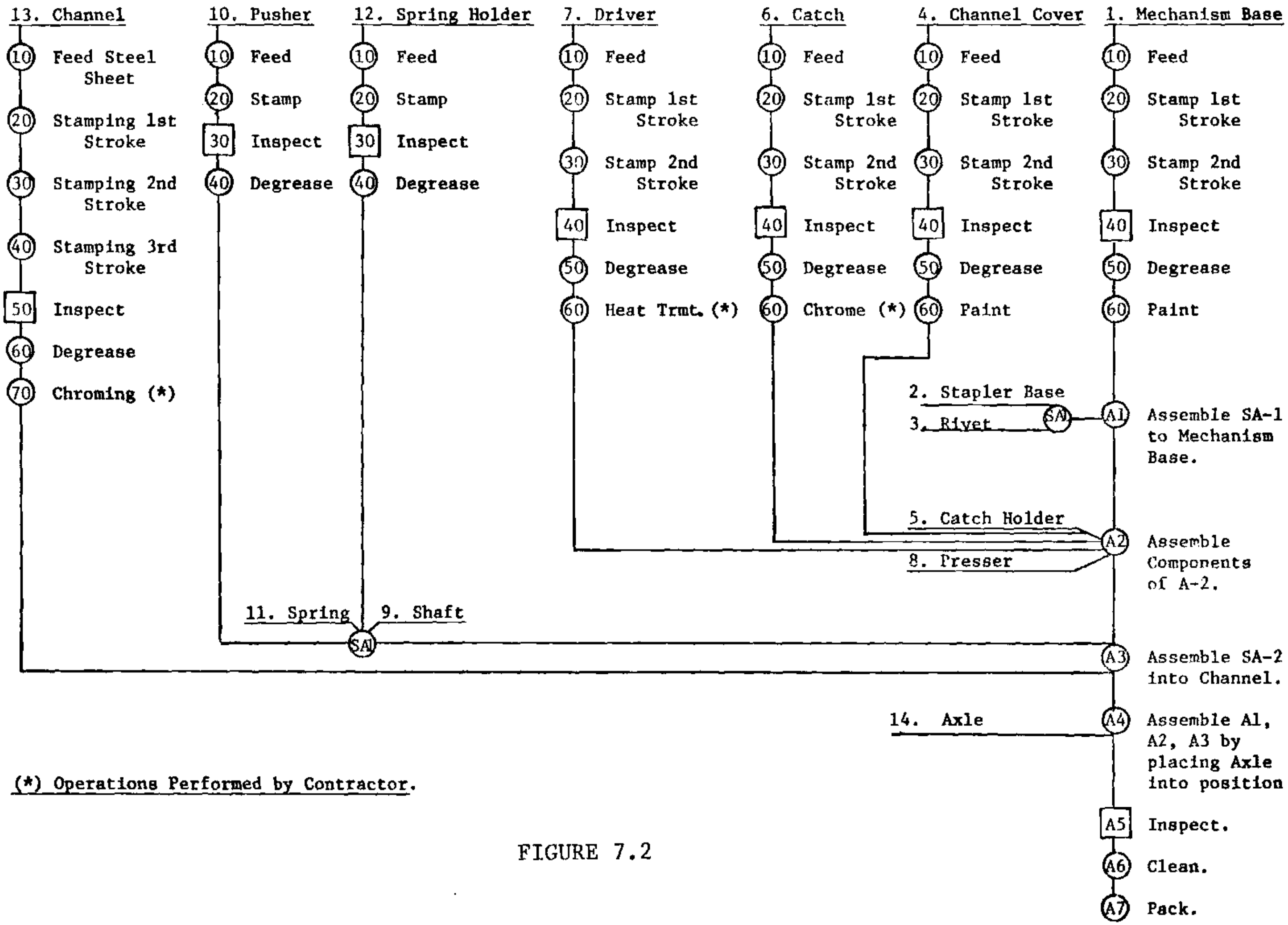


FIGURE 7.2

OPERATIONS PROCESS CHART FOR STAPLER

This does not require unrealistic simplification of operations, since all items being stamped are also degreased. This area (step) is assigned two alternate configurations, which are actually identical pieces of equipment, but which have different staffing requirements. Thus we have an example of how the invariable shift composition assumption need not be as restrictive as it might appear.

The problem of how to handle the contractor modification of parts is overcome by taking a slightly different perspective. If a unit of "contractor service" is defined as the contractor action necessary to treat one part, then the contractor service unit can be costed at the averaged cost per part processed. Since the model "purchases" units of contractor service, they may be treated as any other raw material.

The revised flow of production is illustrated in Figure 7.3. Contractor services are inputs to certain items produced in the stamping and degreasing area. Channel cover and Mechanism Base are separated into two items each to indicate their different states before and after painting.

At this point it is instructive to look at the development of the mechanical difficulty factors associated with items produced in the stamping and degreasing area. Letting α_j be the factor applicable to item j, we wish to find

$$\alpha_j : \frac{1}{\mathrm{OUTPUT}_j} * \alpha_j = \frac{1}{\mathrm{OUTPUT}_M}$$

$$\Rightarrow \alpha_j = \frac{\mathrm{OUTPUT}_M}{\mathrm{OUTPUT}_j}, \; \alpha \in (0,\infty)$$

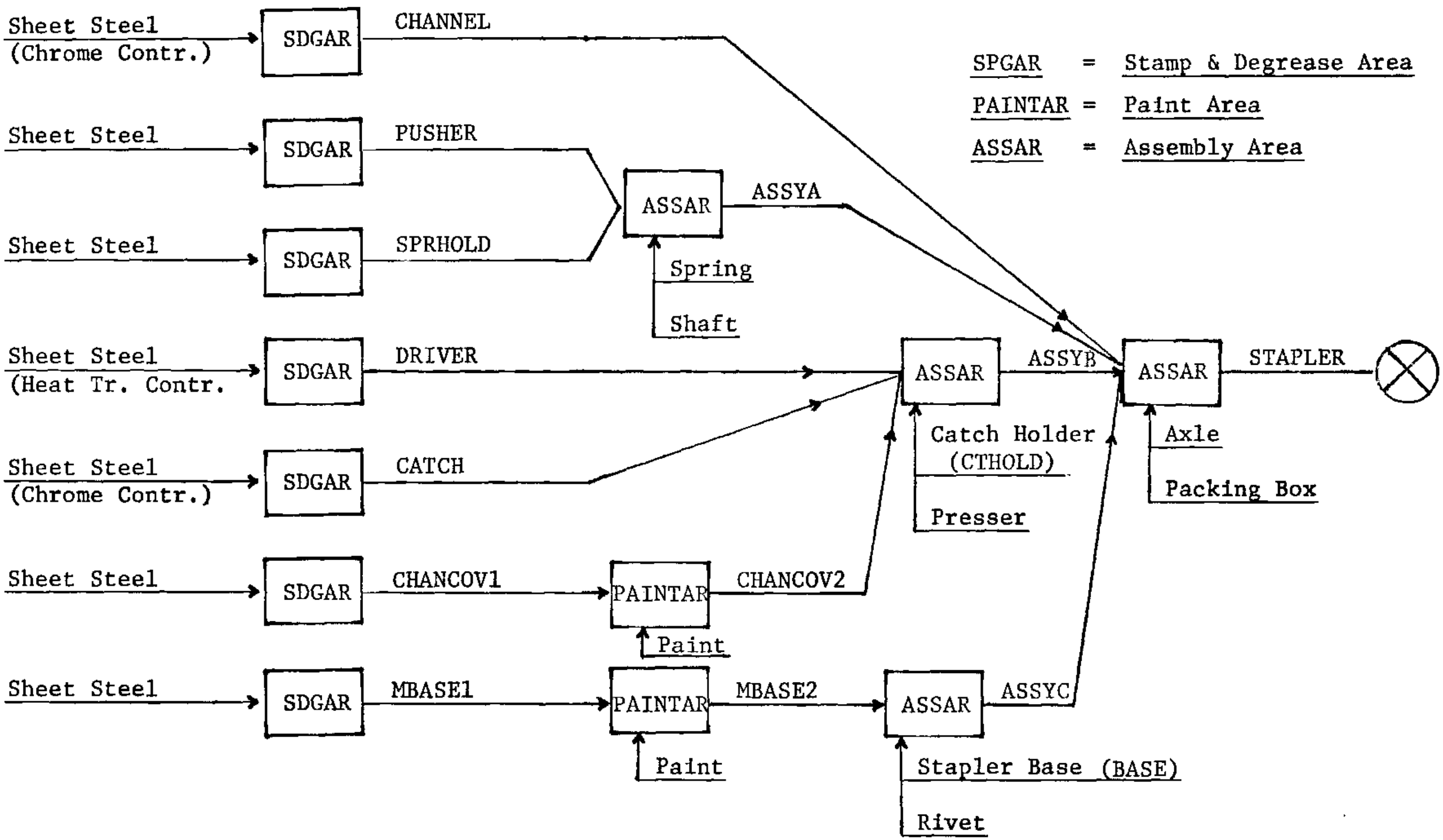


FIGURE 7.3

PRODUCTION FLOW CHART FOR STAPLER

where

$$OUTPUT_M = \text{"Maximum" output rate (units/hr)}$$

$$OUTPUT_j = \text{Actual output rate for item}_j \text{ (units/hr)}$$

Actual output for all items produced in the stamping and degreasing area are shown in Table 7.1. A logical choice for a "maximum" output rate is an estimate of the maximum feasible rate for the equipment in question.

Table 7.1 Stapler Venture: Mechanical Difficulty Factors

Item	Actual Output	α
MBASE1	486	18.89
CHANCOV1	486	18.89
CATCH	1313	6.99
DRIVER	486	18.89
SPRHOLD	10,200	0.9
PUSHER	10,200	0.9
CHANNEL	268	34.25

Maximum attainable rate: 9180 (90% of max. rated capacity)

Use of this value for maximum output yielded the data in Table 7.2. Examination of the surplus capacity information indicates a tremendous amount of overcapacity throughout the planning period. In fact, this much excess capacity does not exist. The high surplus capacity figures are simply a result of a misspecification of maximum output rate, as

Table 7.2 Stamping and Degreasing Area Operations
Profile: "High" Surplus

OPERATIONS PROFILE: PROCESS STEP- SDGAR

MONTH	PC USED	HOURS SCHEDULED	HOURS UTILIZED	HOURS DOWN	SHIFTS PER DAY	OT HRS PER MAN, PER SHIFT	ACTUAL OUTPUT (UNITS)	SURPLUS CAPACITY: UNITS	FRACTION OF OUTPUT
1	ST/DG1	1.2	1.2	.01	1.	0.0	569.0	*******	2098.86
2	ST/DG1	2.3	2.3	.01	1.	0.0	1137.0	*******	1043.24
3	ST/DG1	9.5	9.5	.05	1.	0.0	4655.0	*******	244.07
4	ST/DG1	9.5	9.5	.05	1.	0.0	4655.0	*******	244.07
5	ST/DG1	9.5	9.5	.05	1.	0.0	4655.0	*******	244.07
6	ST/DG1	9.5	9.5	.05	1.	0.0	4655.0	*******	244.07
7	ST/DG1	9.5	9.5	.05	1.	0.0	4655.0	*******	244.07
8	ST/DG1	9.5	9.5	.05	1.	0.0	4655.0	*******	244.07
9	ST/DG1	9.5	9.5	.05	1.	0.0	4655.0	*******	244.07
10	ST/DG1	9.5	9.5	.05	1.	0.0	4655.0	*******	244.07
11	ST/DG1	9.5	9.5	.05	1.	0.0	4655.0	*******	244.07
12	ST/DG1	9.5	9.5	.05	1.	0.0	4655.0	*******	244.07
13	ST/DG1	30.7	30.5	.15	1.	0.0	14982.0	989251.	66.03
14	ST/DG1	30.7	30.5	.15	1.	0.0	14982.0	989251.	66.03
15	ST/DG1	30.7	30.5	.15	1.	0.0	14982.0	989251.	66.03
16	ST/DG1	30.7	30.5	.15	1.	0.0	14982.0	989251.	66.03
17	ST/DG1	30.7	30.5	.15	1.	0.0	14982.0	989251.	66.03
18	ST/DG1	30.7	30.5	.15	1.	0.0	14982.0	989251.	66.03
19	ST/DG1	30.7	30.5	.15	1.	0.0	14982.0	989251.	66.03
20	ST/DG1	30.7	30.5	.15	1.	0.0	14982.0	989251.	66.03
21	ST/DG1	30.7	30.5	.15	1.	0.0	14982.0	989251.	66.03
22	ST/DG1	30.7	30.5	.15	1.	0.0	14982.0	989251.	66.03
23	ST/DG1	30.7	30.5	.15	1.	0.0	14982.0	989251.	66.03
24	ST/DG1	30.8	30.6	.15	1.	0.0	15010.0	988852.	65.88
25	ST/DG1	83.2	82.8	.42	1.	0.0	40606.0	624792.	15.39
26	ST/DG1	83.2	82.8	.42	1.	0.0	40606.0	624792.	15.39
27	ST/DG1	83.2	82.8	.42	1.	0.0	40606.0	624792.	15.39
28	ST/DG1	83.2	82.8	.42	1.	0.0	40606.0	624792.	15.39
29	ST/DG1	83.2	82.8	.42	1.	0.0	40606.0	624792.	15.39
30	ST/DG1	83.2	82.8	.42	1.	0.0	40606.0	624792.	15.39
31	ST/DG1	83.2	82.8	.42	1.	0.0	40606.0	624792.	15.39
32	ST/DG1	83.2	82.8	.42	1.	0.0	40606.0	624792.	15.39
33	ST/DG1	83.2	82.8	.42	1.	0.0	40606.0	624792.	15.39
34	ST/DG1	83.2	82.8	.42	1.	0.0	40606.0	624792.	15.39
35	ST/DG1	83.2	82.8	.42	1.	0.0	40606.0	624792.	15.39
36	ST/DG1	83.3	82.9	.42	1.	0.0	40662.0	623995.	15.35
37	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	367669.	6.27
38	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	367669.	6.27
39	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	367669.	6.27
40	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	367669.	6.27
41	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	367669.	6.27
42	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	367669.	6.27
43	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	367669.	6.27
44	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	367669.	6.27
45	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	367669.	6.27
46	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	367669.	6.27
47	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	367669.	6.27
48	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	367669.	6.27
49	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	276906.	4.26
50	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	276906.	4.26
51	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	276906.	4.26
52	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	276906.	4.26
53	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	276906.	4.26
54	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	276906.	4.26
55	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	276906.	4.26

Table 7.2 cont'd

56	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	276906.	4.26
57	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	276906.	4.26
58	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	276906.	4.26
59	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	276906.	4.26
60	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	276906.	4.26
MONTHLY AVG.:		75.1	74.8	.38	1.	0.0	36673.1	680733.	111.43

OPERATIONS SUMMARY: PROCESS STEP- SUGAR

YEAR	PC USED	HOURS SCHEDULED	HOURS UTILIZED	HOURS DOWN	SHIFTS PER DAY	OT HRS PER MAN, PER SHIFT	ACTUAL OUTPUT (UNITS)	SURPLUS UNITS	CAPACITY: FRACTION OF OUTPUT
1		99.	98.	0.			48256.	********	284.77
2		368.	367.	2.			179812.	********	66.02
3		998.	993.	5.			487328.	7496711.	15.38
4		1443.	1436.	7.			704208.	4412024.	6.27
5		1600.	1592.	8.			780780.	3322878.	4.26

discussed in Section 5.4.2. To arrive at a conservative and more useful set of surplus figures, let $OUTPUT_M$ = 286 units/hour, which is the lowest rate for any item produced. The values of the redefined factors are given below.

	α_j
MBASE1:	0.55
CHANCOV1:	0.55
CATCH:	0.20
DRIVER:	0.55
SPRHOLD:	0.03
PUSHER:	0.03
CHANNEL:	1.00

Table 7.3 illustrates the results of the change in the value of $OUTPUT_M$. While a clear indication of excess capacity still exists, it is in proportions which are more realistic and useful as a planning tool. Note that all data categories except those dealing with surplus are unchanged.

Another construct is used to model a situation not explicitly treated by MVPM. The situation arises because there is no plan to staff the materials handling function. (The original venture planners assumed that there will be with sufficient idle time for workers to satisfy all need for movement and storage of materials). In the context of the model, it is necessary to create a dummy process configuration (SMHEQ) and step (SMHFUNC). It uses no labor or other resources, but requires an investment equal to the cost of materials handling and maintenance-equipment, and will "occupy" floor space equal to the storage area

Table 7.3 Stamping and Degreasing Area Operations
Profile: "Low" Surplus

OPERATIONS PROFILE: PROCESS STEP- SDGAR

MONTH	PC USED	HOURS SCHEDULED	HOURS UTILIZED	HOURS DOWN	SHIFTS PER DAY	OT HRS PER MAN, PER SHIFT	ACTUAL OUTPUT (UNITS)	SURPLUS UNITS	CAPACITY: FRACTION OF OUTPUT
1	ST/DG1	1.2	1.2	.01	1.	0.0	569.0	34865.	61.27
2	ST/DG1	2.3	2.3	.01	1.	0.0	1137.0	34629.	30.46
3	ST/DG1	9.5	9.5	.05	1.	0.0	4655.0	33168.	7.13
4	ST/DG1	9.5	9.5	.05	1.	0.0	4655.0	33168.	7.13
5	ST/DG1	9.5	9.5	.05	1.	0.0	4655.0	33168.	7.13
6	ST/DG1	9.5	9.5	.05	1.	0.0	4655.0	33168.	7.13
7	ST/DG1	9.5	9.5	.05	1.	0.0	4655.0	33168.	7.13
8	ST/DG1	9.5	9.5	.05	1.	0.0	4655.0	33168.	7.13
9	ST/DG1	9.5	9.5	.05	1.	0.0	4655.0	33168.	7.13
10	ST/DG1	9.5	9.5	.05	1.	0.0	4655.0	33168.	7.13
11	ST/DG1	9.5	9.5	.05	1.	0.0	4655.0	33168.	7.13
12	ST/DG1	9.5	9.5	.05	1.	0.0	4655.0	33168.	7.13
13	ST/DG1	30.7	30.5	.15	1.	0.0	14982.0	28880.	1.93
14	ST/DG1	30.7	30.5	.15	1.	0.0	14982.0	28880.	1.93
15	ST/DG1	30.7	30.5	.15	1.	0.0	14982.0	28880.	1.93
16	ST/DG1	30.7	30.5	.15	1.	0.0	14982.0	28880.	1.93
17	ST/DG1	30.7	30.5	.15	1.	0.0	14982.0	28880.	1.93
18	ST/DG1	30.7	30.5	.15	1.	0.0	14982.0	28880.	1.93
19	ST/DG1	30.7	30.5	.15	1.	0.0	14982.0	28880.	1.93
20	ST/DG1	30.7	30.5	.15	1.	0.0	14982.0	28880.	1.93
21	ST/DG1	30.7	30.5	.15	1.	0.0	14982.0	28880.	1.93
22	ST/DG1	30.7	30.5	.15	1.	0.0	14982.0	28880.	1.93
23	ST/DG1	30.7	30.5	.15	1.	0.0	14982.0	28880.	1.93
24	ST/DG1	30.8	30.6	.15	1.	0.0	15010.0	28869.	1.92
25	ST/DG1	83.2	82.8	.42	1.	0.0	40606.0	18240.	.45
26	ST/DG1	83.2	82.8	.42	1.	0.0	40606.0	18240.	.45
27	ST/DG1	83.2	82.8	.42	1.	0.0	40606.0	18240.	.45
28	ST/DG1	83.2	82.8	.42	1.	0.0	40606.0	18240.	.45
29	ST/DG1	83.2	82.8	.42	1.	0.0	40606.0	18240.	.45
30	ST/DG1	83.2	82.8	.42	1.	0.0	40606.0	18240.	.45
31	ST/DG1	83.2	82.8	.42	1.	0.0	40606.0	18240.	.45
32	ST/DG1	83.2	82.8	.42	1.	0.0	40606.0	18240.	.45
33	ST/DG1	83.2	82.8	.42	1.	0.0	40606.0	18240.	.45
34	ST/DG1	83.2	82.8	.42	1.	0.0	40606.0	18240.	.45
35	ST/DG1	83.2	82.8	.42	1.	0.0	40606.0	18240.	.45
36	ST/DG1	83.3	82.9	.42	1.	0.0	40662.0	18217.	.45
37	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	10734.	.18
38	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	10734.	.18
39	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	10734.	.18
40	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	10734.	.18
41	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	10734.	.18
42	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	10734.	.18
43	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	10734.	.18
44	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	10734.	.18
45	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	10734.	.18
46	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	10734.	.18
47	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	10734.	.18
48	ST/DG1	120.2	119.6	.60	1.	0.0	58684.0	10734.	.18
49	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	8084.	.12
50	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	8084.	.12
51	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	8084.	.12
52	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	8084.	.12
53	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	8084.	.12
54	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	8084.	.12
55	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	8084.	.12

Table 7.3 cont'd

56	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	8084.	.12
57	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	8084.	.12
58	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	8084.	.12
59	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	8084.	.12
60	ST/DG1	133.3	132.6	.67	1.	0.0	65065.0	8084.	.12
MONTHLY AVG.:		75.1	74.8	.38	1.	0.0	36673.1	19873.	3.25

OPERATIONS SUMMARY: PROCESS STEP- SOGAR

YEAR	PC USED	HOURS SCHEDULED	HOURS UTILIZED	HOURS DOWN	SHIFTS PER DAY	OT HRS PER MAN, PER SHIFT	ACTUAL OUTPUT (UNITS)	SURPLUS CAPACITY: UNITS	FRACTION OF OUTPUT
1		99.	98.	0.			48256.	401176.	8.31
2		368.	367.	2.			179812.	346550.	1.93
3		998.	993.	5.			487328.	218860.	.45
4		1443.	1436.	7.			704208.	128806.	.18
5		1600.	1592.	8.			780780.	97010.	.12

requirement. Thus its contribution to rental and depreciation cost figures will be accounted for.

Portions of operations and financial reports are contained in Appendix A. As was desired, the operations profile of step SMHFUNC shows no explicit resource utilization.

The Raw Materials Profile of material PAINT affords an excellent example of the raw materials ordering algorithm. The minimum order quantity of ten has a marked effect on the pattern of new orders.

Information on the financial activity of the venture is made available for analysis. Such analysis is not attempted here. It is, however, interesting to note the effect of the exhaustion of all tax loss carry forward at the end of year 4 and the effect it has on most indices of profitability in year 5, even though the gross margin is higher. This is an illustration of the importance of having several meaures of performance available for analysis.

This case provided additional opportunity to examine the validity of model operation. The internal consistency of MVPM was checked by manual verification of selected model generated quantities.

CHAPTER VIII

CONCLUSION AND RECOMMENDATIONS

8.1 Summary

Development of the model set forth in previous chapters began with a review of planning models. The goal in this endeavor was to provide a general background representative of the state-of-the-art, and to create a framework for directed research. To this end, the examination of work by other authors was completed with an attempt to characterize the different models via a multi-attribute classification scheme. This yielded a list of desirable qualities which were lacking in any one model. A subset of these was chosen as the design specifications for the present model. Succeeding chapters have traced the development of the model, ending with an application to an actual venture planning situation.

8.2 Conclusions

In reaching conclusions regarding the present work, one starts with an evaluation of the performance and characteristics of the model vis-a-vis the objectives set forth at the beginning of the thesis. These were the development of a computer-implemented model for use:

A) In new venture planning and feasibility analysis. The application of the model presented in Chapter VII was an indication of how well the MVPM might fit into a real-world planning situation. It was a case containing many items which were not explicitly incorporated in the model. One cannot hope to consider all of the permutations of organizational and operational arrangement that make up the arena wherein business activity occurs. Thus, for a model to be usable, it must be flexible enough to handle non-standard planning problems. The purposefully general characterizations of a venture and its constituent parts and activities, which are the fundamental elements of the MVPM, give it this flexibility.

B) As a tool for educational activity and further research. Communication between the user and the model in a clear and easy to understand command environment is of great potential benefit when the model is used in an educational setting. Once the basic process of characterizing a venture proposal has been mastered, use of the model should be quite straightforward. It is hoped that it will prove to be useful in helping students to understand the concepts and dynamics of new venture feasibility analysis. As will be discussed in the next section, there are numerous avenues for extensions of the current model. Additionally, it may be used in its present form for examination of research problem areas. Thus, the MVPM should also be useful in academic research endeavors.

The MVPM in its present form satisfies the objectives that have guided this research effort. A model has been developed that, within limitations, is both operable and possessed of reasonable scope and capabilities.

The present version of MVPM has incorporated into it many assumptions that severely limit its real-world applicability. Despite this, the scheme of process characterization on which it is founded, should permit it to be useful in many planning situations. Planning activities are becoming more important to business survival, particularly the small or new firm [52,24]. In addition, there is an unfortunate tendency on the part of small business managers not to plan in a formal and organized manner, and to concentrate only on the short-run [25].

In view of this situation, a planning tool such as MVPM can serve as a much needed stimulus for the development of good planning practice on the part of small business managers, or persons seeking to start a new venture. The ease of model use and its clarity of design and methodology combine with its standard-business-form output format to make MVPM an ideal tool for teaching and aiding in implementation of a quantitative planning approach.

8.3 Recommendations

8.3.1 Further Development

There are many aspects of the real-world venture planning environment which a planning model should reflect if it is to be of maximum usefulness. In its present version, MVPM is lacking in some very desirable attributes and capabilities. These form the set of most fruitful directions for further development of the model. The list below is composed of the most important of these.

1) Time varying sales price. Variation of the price at which goods are sold is an important means of coping with the competitive environment for any business. Significant changes in

the cost of goods sold may by themselves also indicate the need for price changes. Extension of the model should allow for user-entry of a price schedule, or, optionally, internal modification of prices in response to measured changes in costs.

2) Investment tax credit. In a real-world planning situation, investment tax credit is often an extremely important consideration in the decision on whether or not to take advantage of an investment opportunity. Thus its inclusion in the model would add greatly to its usefulness in this area.

3) More extensive treatment of lost sales. Lost sales often result in loss of clientele and other significant costs above the cost of revenue foregone. More information regarding lost sales would help the planner-manager to evaluate all costs relative to his situation.

4) The assumption regarding the manner in which debt is repaid is lacking in realism. Some means should be provided for the user to accurately represent the credit conditions in which he must operate.

5) More flexibility in specification of lag time between transactions and actual transfer of cash. The present period of 30 days is rather short when viewed in terms of actual practice.

6) Inclusion of shift differentials as part of personnel resource data.

7) Generation of exception reporting and reports dealing with %

period-to-period changes.

8) Explicit treatment of part-time employment.

9) Payment of dividends and provision for multi-period increases in paid-in-capital.

10) User override of model decisions in the following areas:

   i) Specification of the number of shifts per day for a given process step in a given month.

   ii) The timing of capital expansion.

11) Alternative policies for:

   i) Cash management. Interesting policies to explore would be those of Spradlin and Konstans [58], and Stone [60].

   ii) Depreciation. Double declining balance, SOYD, and sinking fund methods should be programmed into the model as user options.

   iii) External Funding, e.g., use of notes, bonds and, generally, financial instruments of varying costs.

   iv) Staffing of operations. Options might include variable shift sizes and composition.

12) Generally, relaxation of many of the assumptions which were stated in Chapter IV. The most important of these would be:

   i) Allowing back ordering.

   ii) Use of purchased facilities.

   iii) Consideration of the effects of inflation in the national economy, and cost escalation in specific inputs to production (including labor services).

   iv) More flexible treatment of asset retirement.

v) Inclusion of more detail regarding venture startup activities.

13) Generally, greater scope and flexibility in model input and output.

14) Local suboptimization in selected model segments.

8.3.2 Documentation

As reference to the program listing in Appendix C will show, the MVPM program units are well internally documented. External documentation, however, is limited to the information contained in the thesis. For the model to be applied for any purpose by unsophisticated users, more user-oriented description of model functioning and I/O must be made available.

8.3.3 Implementation and Extension

As shown in Section 8.3.1, although (or because) the MVPM is sound and usable as it exists at present, there are many points of departure for extension of breadth and sophistication of methodology. Experience described by several of the authors cited in Chapter II has demonstrated how this process of model enhancement is aided, if not motivated, by significant levels of model usage. In the context of the model described here, this might best be accomplished through the auspices of an agency such as the Small Business Administration, the National Chamber of Commerce, the American Banking Association, or the Financial Executives Institute (among many others). Given the kind of support needed to develop comprehensive documentation, and to bring the model in program form up to "production" code standards, the MVPM could be made available on a wide scale for educational and business planning use.

APPENDIX A

STAPLER VENTURE: OPERATIONS AND FINANCIAL REPORTS

MANUFACTURING VENTURE PLANNING MODEL ----- VERSION 1.0 ----- GEORGIA INSTITUTE OF TECHNOLOGY, JULY 1978

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     ***** STAPLER MANUFACTURER - RUN OF BASE CASE SCENARIO *****

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OPERATIONS PROFILE: PROCESS STEP- ASSAR

MONTH	PC USED	HOURS SCHEDULED	HOURS UTILIZED	HOURS DOWN	SHIFTS PER DAY	OT HRS PER MAN, PER SHIFT	ACTUAL OUTPUT (UNITS)	SURPLUS CAPACITY: UNITS	FRACTION OF OUTPUT
1	ASSEQ	.6	.6	0.00	1.	0.0	324.0	95369.	294.35
2	ASSEQ	1.2	1.2	0.00	1.	0.0	648.0	95045.	146.67
3	ASSEQ	4.8	4.8	0.00	1.	0.0	2652.0	93041.	35.08
4	ASSEQ	4.8	4.8	0.00	1.	0.0	2652.0	93041.	35.08
5	ASSEQ	4.8	4.8	0.00	1.	0.0	2652.0	93041.	35.08
6	ASSEQ	4.8	4.8	0.00	1.	0.0	2652.0	93041.	35.08
7	ASSEQ	4.8	4.8	0.00	1.	0.0	2652.0	93041.	35.08
8	ASSEQ	4.8	4.8	0.00	1.	0.0	2652.0	93041.	35.08
9	ASSEQ	4.8	4.8	0.00	1.	0.0	2652.0	93041.	35.08
10	ASSEQ	4.8	4.8	0.00	1.	0.0	2652.0	93041.	35.08
11	ASSEQ	4.8	4.8	0.00	1.	0.0	2652.0	93041.	35.08
12	ASSEQ	4.8	4.8	0.00	1.	0.0	2652.0	93041.	35.08
13	ASSEQ	15.4	15.4	0.00	1.	0.0	8536.0	87157.	10.21
14	ASSEQ	15.4	15.4	0.00	1.	0.0	8536.0	87157.	10.21
15	ASSEQ	15.4	15.4	0.00	1.	0.0	8536.0	87157.	10.21
16	ASSEQ	15.4	15.4	0.00	1.	0.0	8536.0	87157.	10.21
17	ASSEQ	15.4	15.4	0.00	1.	0.0	8536.0	87157.	10.21
18	ASSEQ	15.4	15.4	0.00	1.	0.0	8536.0	87157.	10.21
19	ASSEQ	15.4	15.4	0.00	1.	0.0	8536.0	87157.	10.21
20	ASSEQ	15.4	15.4	0.00	1.	0.0	8536.0	87157.	10.21
21	ASSEQ	15.4	15.4	0.00	1.	0.0	8536.0	87157.	10.21
22	ASSEQ	15.4	15.4	0.00	1.	0.0	8536.0	87157.	10.21
23	ASSEQ	15.4	15.4	0.00	1.	0.0	8536.0	87157.	10.21
24	ASSEQ	15.5	15.5	0.00	1.	0.0	8552.0	87141.	10.19
25	ASSEQ	41.9	41.9	0.00	1.	0.0	23136.0	72557.	3.14
26	ASSEQ	41.9	41.9	0.00	1.	0.0	23136.0	72557.	3.14
27	ASSEQ	41.9	41.9	0.00	1.	0.0	23136.0	72557.	3.14
28	ASSEQ	41.9	41.9	0.00	1.	0.0	23136.0	72557.	3.14
29	ASSEQ	41.9	41.9	0.00	1.	0.0	23136.0	72557.	3.14
30	ASSEQ	41.9	41.9	0.00	1.	0.0	23136.0	72557.	3.14
31	ASSEQ	41.9	41.9	0.00	1.	0.0	23136.0	72557.	3.14
32	ASSEQ	41.9	41.9	0.00	1.	0.0	23136.0	72557.	3.14
33	ASSEQ	41.9	41.9	0.00	1.	0.0	23136.0	72557.	3.14
34	ASSEQ	41.9	41.9	0.00	1.	0.0	23136.0	72557.	3.14
35	ASSEQ	41.9	41.9	0.00	1.	0.0	23136.0	72557.	3.14
36	ASSEQ	41.9	41.9	0.00	1.	0.0	23168.0	72525.	3.13
37	ASSEQ	60.5	60.5	0.00	1.	0.0	33436.0	62257.	1.86
38	ASSEQ	60.5	60.5	0.00	1.	0.0	33436.0	62257.	1.86
39	ASSEQ	60.5	60.5	0.00	1.	0.0	33436.0	62257.	1.86
40	ASSEQ	60.5	60.5	0.00	1.	0.0	33436.0	62257.	1.86
41	ASSEQ	60.5	60.5	0.00	1.	0.0	33436.0	62257.	1.86
42	ASSEQ	60.5	60.5	0.00	1.	0.0	33436.0	62257.	1.86
43	ASSEQ	60.5	60.5	0.00	1.	0.0	33436.0	62257.	1.86
44	ASSEQ	60.5	60.5	0.00	1.	0.0	33436.0	62257.	1.86
45	ASSEQ	60.5	60.5	0.00	1.	0.0	33436.0	62257.	1.86
46	ASSEQ	60.5	60.5	0.00	1.	0.0	33436.0	62257.	1.86
47	ASSEQ	60.5	60.5	0.00	1.	0.0	33436.0	62257.	1.86
48	ASSEQ	60.5	60.5	0.00	1.	0.0	33436.0	62257.	1.86
49	ASSEQ	67.1	67.1	0.00	1.	0.0	37072.0	58621.	1.58
50	ASSEQ	67.1	67.1	0.00	1.	0.0	37072.0	58621.	1.58
51	ASSEQ	67.1	67.1	0.00	1.	0.0	37072.0	58621.	1.58
52	ASSEQ	67.1	67.1	0.00	1.	0.0	37072.0	58621.	1.58
53	ASSEQ	67.1	67.1	0.00	1.	0.0	37072.0	58621.	1.58
54	ASSEQ	67.1	67.1	0.00	1.	0.0	37072.0	58621.	1.58
55	ASSEQ	67.1	67.1	0.00	1.	0.0	37072.0	58621.	1.58

OPERATIONS PROFILE: PROCESS STEP- SMHFUNC

MONTH	PC USED	HOURS SCHEDULED	HOURS UTILIZED	HOURS DOWN	SHIFTS PER DAY	OT HRS PER MAN, PER SHIFT	ACTUAL OUTPUT (UNITS)	SURPLUS CAPACITY: UNITS	SURPLUS CAPACITY: FRACTION OF OUTPUT
1	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
2	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
3	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
4	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
5	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
6	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
7	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
8	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
9	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
10	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
11	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
12	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
13	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
14	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
15	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
16	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
17	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
18	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
19	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
20	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
21	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
22	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
23	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
24	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
25	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
26	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
27	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
28	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
29	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
30	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
31	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
32	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
33	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
34	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
35	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
36	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
37	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
38	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
39	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
40	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
41	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
42	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
43	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
44	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
45	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
46	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
47	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
48	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
49	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
50	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
51	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
52	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
53	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
54	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00
55	SMHEQ	0.0	0.0	0.00	1.	0.0	0.0	*******	0.00

PRODUCTION PROFILE: PRODUCTION ITEM- STAPLER **STAPLER, ASSEMBLED, INSP., PACKAGED. **

MONTH	USER INPUT PRODUCTION	REJECT AMOUNT	ACTUAL PRODUCTION	INVENTORY: BEG OF MONTH	DEMAND UNITS	GROSS SALES UNITS	LOST SALES UNITS	INVENTORY: END OF MONTH
1	80.	1.	81.	0.	80.	80.	0.	0.
2	160.	2.	162.	0.	160.	160.	0.	0.
3	656.	7.	663.	0.	240.	240.	0.	416.
4	656.	7.	663.	416.	400.	400.	0.	672.
5	656.	7.	663.	672.	560.	560.	0.	768.
6	656.	7.	663.	768.	400.	400.	0.	1024.
7	656.	7.	663.	1024.	320.	320.	0.	1360.
8	656.	7.	663.	1360.	560.	560.	0.	1456.
9	656.	7.	663.	1456.	800.	800.	0.	1312.
10	656.	7.	663.	1312.	960.	960.	0.	1008.
11	656.	7.	663.	1008.	1120.	1120.	0.	544.
12	656.	7.	663.	544.	1200.	1200.	0.	0.
13	2113.	21.	2134.	0.	1440.	1440.	0.	673.
14	2113.	21.	2134.	673.	1600.	1600.	0.	1186.
15	2113.	21.	2134.	1186.	1760.	1760.	0.	1539.
16	2113.	21.	2134.	1539.	2000.	2000.	0.	1652.
17	2113.	21.	2134.	1652.	2240.	2240.	0.	1525.
18	2113.	21.	2134.	1525.	1840.	1840.	0.	1798.
19	2113.	21.	2134.	1798.	1600.	1600.	0.	2311.
20	2113.	21.	2134.	2311.	2000.	2000.	0.	2424.
21	2113.	21.	2134.	2424.	2240.	2240.	0.	2297.
22	2113.	21.	2134.	2297.	2560.	2560.	0.	1850.
23	2113.	21.	2134.	1850.	2880.	2880.	0.	1083.
24	2117.	21.	2138.	1083.	3200.	3200.	0.	0.
25	5726.	58.	5784.	0.	3600.	3600.	0.	2126.
26	5726.	58.	5784.	2126.	4000.	4000.	0.	3852.
27	5726.	58.	5784.	3852.	4880.	4880.	0.	4698.
28	5726.	58.	5784.	4698.	5440.	5440.	0.	4984.
29	5726.	58.	5784.	4984.	6000.	6000.	0.	4710.
30	5726.	58.	5784.	4710.	5260.	5260.	0.	5176.
31	5726.	58.	5784.	5176.	4480.	4480.	0.	6422.
32	5726.	58.	5784.	6422.	6000.	6000.	0.	6148.
33	5726.	58.	5784.	6148.	6560.	6560.	0.	5314.
34	5726.	58.	5784.	5314.	7040.	7040.	0.	4000.
35	5726.	58.	5784.	4000.	7520.	7520.	0.	2206.
36	5734.	58.	5792.	2206.	8000.	7940.	60.	0.
37	8275.	84.	8359.	0.	8300.	8275.	25.	0.
38	8275.	84.	8359.	0.	8374.	8275.	99.	0.
39	8275.	84.	8359.	0.	8448.	8275.	173.	0.
40	8275.	84.	8359.	0.	8522.	8275.	247.	0.
41	8275.	84.	8359.	0.	8596.	8275.	321.	0.
42	8275.	84.	8359.	0.	8670.	8275.	395.	0.
43	8275.	84.	8359.	0.	8743.	8275.	468.	0.
44	8275.	84.	8359.	0.	8817.	8275.	542.	0.
45	8275.	84.	8359.	0.	8891.	8275.	616.	0.
46	8275.	84.	8359.	0.	8965.	8275.	690.	0.
47	8275.	84.	8359.	0.	9039.	8275.	764.	0.
48	8275.	84.	8359.	0.	9113.	8275.	838.	0.

RAW MATERIALS PROFILE: RAW MATERIAL- PAINT **ACRYLIC ENAMEL, SLVNT. BASE, FAST DRY.

MONTH	AMOUNT REQUIRED	INVENTORY: BEG OF MONTH	AMOUNT RECEIVED	INVENTORY: END OF MONTH	AMOUNT NEW ORDERS
STARTUP PERIOD					10.00
1	.32	0.00	10.00	9.68	0.00
2	.65	9.68	0.00	9.03	0.00
3	2.65	9.03	0.00	6.38	0.00
4	2.65	6.38	0.00	3.72	0.00
5	2.65	3.72	10.00	11.07	10.00
6	2.65	11.07	0.00	8.42	0.00
7	2.65	8.42	0.00	5.77	0.00
8	2.65	5.77	0.00	3.12	0.00
9	2.65	3.12	10.00	10.46	10.00
10	2.65	10.46	0.00	7.81	0.00
11	2.65	7.81	0.00	5.16	0.00
12	2.65	5.16	0.00	2.51	0.00
13	8.54	2.51	14.56	8.54	14.56
14	8.54	8.54	0.00	0.00	0.00
15	8.54	0.00	17.07	8.54	17.07
16	8.54	8.54	0.00	0.00	0.00
17	8.54	0.00	17.07	8.54	17.07
18	8.54	8.54	0.00	0.00	0.00
19	8.54	0.00	17.07	8.54	17.07
20	8.54	8.54	0.00	0.00	0.00
21	8.54	0.00	17.07	8.54	17.07
22	8.54	8.54	0.00	0.00	0.00
23	8.54	0.00	17.09	8.55	17.09
24	8.55	8.55	0.00	0.00	0.00
25	23.14	0.00	23.14	0.00	23.14
26	23.14	0.00	23.14	0.00	23.14
27	23.14	0.00	23.14	0.00	23.14
28	23.14	0.00	23.14	0.00	23.14
29	23.14	0.00	23.14	0.00	23.14
30	23.14	0.00	23.14	0.00	23.14
31	23.14	0.00	23.14	0.00	23.14
32	23.14	0.00	23.14	0.00	23.14
33	23.14	0.00	23.14	0.00	23.14
34	23.14	0.00	23.14	0.00	23.14
35	23.14	0.00	23.14	0.00	23.14
36	23.17	0.00	23.17	0.00	23.17
37	33.44	0.00	33.44	0.00	33.44
38	33.44	0.00	33.44	0.00	33.44
39	33.44	0.00	33.44	0.00	33.44
40	33.44	0.00	33.44	0.00	33.44
41	33.44	0.00	33.44	0.00	33.44
42	33.44	0.00	33.44	0.00	33.44
43	33.44	0.00	33.44	0.00	33.44
44	33.44	0.00	33.44	0.00	33.44
45	33.44	0.00	33.44	0.00	33.44
46	33.44	0.00	33.44	0.00	33.44
47	33.44	0.00	33.44	0.00	33.44
48	33.44	0.00	33.44	0.00	33.44
49	37.07	0.00	37.07	0.00	37.07
50	37.07	0.00	37.07	0.00	37.07
51	37.07	0.00	37.07	0.00	37.07
52	37.07	0.00	37.07	0.00	37.07
53	37.07	0.00	37.07	0.00	37.07
54	37.07	0.00	37.07	0.00	37.07
55	37.07	0.00	37.07	0.00	37.07

RAW MATERIALS PROFILE: RAW MATERIAL- CONT/HT **CONTRACTOR SERVICES- HEAT TREATING.

MONTH	AMOUNT REQUIRED	INVENTORY: BEG OF MONTH	AMOUNT RECEIVED	INVENTORY: END OF MONTH	AMOUNT NEW ORDERS
STARTUP PERIOD					0.00
1	81.00	0.00	81.00	0.00	81.00
2	162.00	0.00	162.00	0.00	162.00
3	663.00	0.00	663.00	0.00	663.00
4	663.00	0.00	663.00	0.00	663.00
5	663.00	0.00	663.00	0.00	663.00
6	663.00	0.00	663.00	0.00	663.00
7	663.00	0.00	663.00	0.00	663.00
8	663.00	0.00	663.00	0.00	663.00
9	663.00	0.00	663.00	0.00	663.00
10	663.00	0.00	663.00	0.00	663.00
11	663.00	0.00	663.00	0.00	663.00
12	663.00	0.00	663.00	0.00	663.00
13	2134.00	0.00	2134.00	0.00	2134.00
14	2134.00	0.00	2134.00	0.00	2134.00
15	2134.00	0.00	2134.00	0.00	2134.00
16	2134.00	0.00	2134.00	0.00	2134.00
17	2134.00	0.00	2134.00	0.00	2134.00
18	2134.00	0.00	2134.00	0.00	2134.00
19	2134.00	0.00	2134.00	0.00	2134.00
20	2134.00	0.00	2134.00	0.00	2134.00
21	2134.00	0.00	2134.00	0.00	2134.00
22	2134.00	0.00	2134.00	0.00	2134.00
23	2134.00	0.00	2134.00	0.00	2134.00
24	2138.00	0.00	2138.00	0.00	2138.00
25	5784.00	0.00	5784.00	0.00	5784.00
26	5784.00	0.00	5784.00	0.00	5784.00
27	5784.00	0.00	5784.00	0.00	5784.00
28	5784.00	0.00	5784.00	0.00	5784.00
29	5784.00	0.00	5784.00	0.00	5784.00
30	5784.00	0.00	5784.00	0.00	5784.00
31	5784.00	0.00	5784.00	0.00	5784.00
32	5784.00	0.00	5784.00	0.00	5784.00
33	5784.00	0.00	5784.00	0.00	5784.00
34	5784.00	0.00	5784.00	0.00	5784.00
35	5784.00	0.00	5784.00	0.00	5784.00
36	5792.00	0.00	5792.00	0.00	5792.00
37	8359.00	0.00	8359.00	0.00	8359.00
38	8359.00	0.00	8359.00	0.00	8359.00
39	8359.00	0.00	8359.00	0.00	8359.00
40	8359.00	0.00	8359.00	0.00	8359.00
41	8359.00	0.00	8359.00	0.00	8359.00
42	8359.00	0.00	8359.00	0.00	8359.00
43	8359.00	0.00	8359.00	0.00	8359.00
44	8359.00	0.00	8359.00	0.00	8359.00
45	8359.00	0.00	8359.00	0.00	8359.00
46	8359.00	0.00	8359.00	0.00	8359.00
47	8359.00	0.00	8359.00	0.00	8359.00
48	8359.00	0.00	8359.00	0.00	8359.00
49	9268.00	0.00	9268.00	0.00	9268.00
50	9268.00	0.00	9268.00	0.00	9268.00
51	9268.00	0.00	9268.00	0.00	9268.00
52	9268.00	0.00	9268.00	0.00	9268.00
53	9268.00	0.00	9268.00	0.00	9268.00
54	9268.00	0.00	9268.00	0.00	9268.00
55	9268.00	0.00	9268.00	0.00	9268.00

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******** MANUFACTURING VENTURE PLANNING MODEL ----- VERSION 1.0 ----- GEORGIA INSTITUTE OF TECHNOLOGY, JULY 1978 ********
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     *****$$$$$ BASE CASE, FINANCIAL SECTION $$$$$*****

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NET INCOME STATEMENT FOR YEAR 3

	($100)	($100)
NET SALES		4570.
COST OF GOODS SOLD:		
FINISHED GOODS INVENTORY (BOP)	0.	

COST OF GOODS PRODUCED:		
COST OF RAW MATERIALS USED:		
RM INVENTORY (BOP)	0.	
RM RECEIVED	2467.	
RM INVENTORY (EOP)	0.	

	2467.	
PLANT WAGES AND SALARIES	347.	
PLANT LABOR HIRE/FIRE COSTS	0.	
PLANT EQIPMENT DEPRECIATION	24.	
PLANT RENTAL EXPENSE	38.	
PLANT OVERHEAD	44.	
PLANT ENERGY/UTILITY COSTS	11.	
PAYROLL TAXES & FRINGE BENEFITS	90.	
INVENTORY TAX	0.	
EQUIPMENT TAX	25.	

	3046.	
FINISHED GOODS INVENTORY (EOP)	0.	3046.
	-------	-------
GROSS INCOME		1524.
SALES AND ADMINISTRATIVE EXPENSE:		
SALES AND MARKETING EXPENSE	554.	
ADMINISTRATIVE SALARIES	272.	
OFFICE EQUIPMENT DEPRECIATION	1.	
OTHER ADMINISTRATIVE EXPENSES	101.	927.
	-------	-------
NET OPERATING INCOME		596.
INTEREST EXPENSE		168.

NET INCOME BEFORE INCOME TAXES		428.
INCOME TAX EXPENSE		0.

NET INCOME AFTER INCOME TAXES		428.
		=======
OPERATING LOSS:		
CUMULATIVE		839.

NET INCOME STATEMENT FOR YEAR 4

	($100)	($100)
NET SALES		6603.
COST OF GOODS SOLD:		
FINISHED GOODS INVENTORY (BOP)	0.	

COST OF GOODS PRODUCED:		
COST OF RAW MATERIALS USED:		
RM INVENTORY (BOP)	0.	
RM RECEIVED	3561.	
RM INVENTORY (EOP)	0.	

	3561.	
PLANT WAGES AND SALARIES	347.	
PLANT LABOR HIRE/FIRE COSTS	0.	
PLANT EQIPMENT DEPRECIATION	24.	
PLANT RENTAL EXPENSE	38.	
PLANT OVERHEAD	64.	
PLANT ENERGY/UTILITY COSTS	16.	
PAYROLL TAXES & FRINGE BENEFITS	90.	
INVENTORY TAX	0.	
EQUIPMENT TAX	25.	

	4164.	
FINISHED GOODS INVENTORY (EOP)	0.	4164.
	-------	-------
GROSS INCOME		2439.
SALES AND ADMINISTRATIVE EXPENSE:		
SALES AND MARKETING EXPENSE	899.	
ADMINISTRATIVE SALARIES	305.	
OFFICE EQUIPMENT DEPRECIATION	2.	
OTHER ADMINISTRATIVE EXPENSES	97.	1302.
	-------	-------
NET OPERATING INCOME		1137.
INTEREST EXPENSE		83.

NET INCOME BEFORE INCOME TAXES		1053.
INCOME TAX EXPENSE		56.

NET INCOME AFTER INCOME TAXES		998.
		=======
OPERATING LOSS:		
CUMULATIVE		0.

NET INCOME STATEMENT FOR YEAR 5

	($100)	($100)
NET SALES		7322.
COST OF GOODS SOLD:		
FINISHED GOODS INVENTORY (BOP)	0.	

COST OF GOODS PRODUCED:		
COST OF RAW MATERIALS USED:		
RM INVENTORY (BOP)	0.	
RM RECEIVED	3947.	
RM INVENTORY (EOP)	0.	

	3947.	
PLANT WAGES AND SALARIES	347.	
PLANT LABOR HIRE/FIRE COSTS	0.	
PLANT EQIPMENT DEPRECIATION	24.	
PLANT RENTAL EXPENSE	38.	
PLANT OVERHEAD	71.	
PLANT ENERGY/UTILITY COSTS	17.	
PAYROLL TAXES & FRINGE BENEFITS	90.	
INVENTORY TAX	0.	
EQUIPMENT TAX	25.	

	4559.	
FINISHED GOODS INVENTORY (EOP)	0.	4559.
	-------	-------
GROSS INCOME		2762.
SALES AND ADMINISTRATIVE EXPENSE:		
SALES AND MARKETING EXPENSE	1023.	
ADMINISTRATIVE SALARIES	330.	
OFFICE EQUIPMENT DEPRECIATION	2.	
OTHER ADMINISTRATIVE EXPENSES	104.	1459.
	-------	-------
NET OPERATING INCOME		1303.
INTEREST EXPENSE		12.

NET INCOME BEFORE INCOME TAXES		1291.
INCOME TAX EXPENSE		620.

NET INCOME AFTER INCOME TAXES		672.
		=======
OPERATING LOSS:		
CUMULATIVE		0.

FINANCIAL RATIO ANALYSIS: YEAR 4

MEASURES OF LIQUIDITY

CURRENT RATIO	QUICK RATIO	FINISHED GOODS INVENTORY: TURNOVER	FINISHED GOODS INVENTORY: AVG. DAYS IN	RAW MATERIALS INVENTORY: TURNOVER	RAW MATERIALS INVENTORY: AVG. DAYS IN
2.37	2.37	******	.00	******	.00

LONG TERM FINANCIAL STRENGTH

DEBT TO EQUITY RATIO	TIMES-INTEREST-EARNED
1.46	13.65

OPERATING EFFICIENCY

OPERATING RATIO
.83

PROFITABILITY

GROSS PROFIT MARGIN	NET PROFIT MARGIN	RETURN ON OWNER EQUITY	RETURN ON TOTAL ASSETS
.37	.15	3.86	1.03

NOTE: ASTERISKS (******) INDICATE THAT INDEX IS VERY LARGE OR CANNOT BE COMPUTED WITH CURRENT YEAR'S DATA.

FINANCIAL RATIO ANALYSIS: YEAR 5

MEASURES OF LIQUIDITY

CURRENT RATIO	QUICK RATIO	FINISHED GOODS INVENTORY: TURNOVER	FINISHED GOODS INVENTORY: AVG. DAYS IN	RAW MATERIALS INVENTORY: TURNOVER	RAW MATERIALS INVENTORY: AVG. DAYS IN
2.57	2.57	******	.00	******	.00

LONG TERM FINANCIAL STRENGTH

DEBT TO EQUITY RATIO	TIMES-INTEREST-EARNED
0.00	108.51

OPERATING EFFICIENCY

OPERATING RATIO
.82

PROFITABILITY

GROSS PROFIT MARGIN	NET PROFIT MARGIN	RETURN ON OWNER EQUITY	RETURN ON TOTAL ASSETS
.38	.09	.72	.47

NOTE: ASTERISKS (******) INDICATE THAT INDEX IS VERY LARGE OR CANNOT BE COMPUTED WITH CURRENT YEAR'S DATA.

MONTHLY NET CASH FLOW

=====>RANGE: -64000.00 TO 11190.00.

1	-64000.00
2	-2291.10
3	597.01
4	816.34
5	727.96
6	619.83
7	743.03
8	797.56
9	668.38
10	576.93
11	441.65
12	342.54
13	394.40
14	756.30
15	900.59
16	714.53
17	428.17
18	249.05
19	502.98
20	698.41
21	421.94
22	349.48
23	94.10
24	.00
25	-76.29
26	689.61
27	935.84
28	240.78
29	.00
30	-211.75
31	-670.59
32	172.32
33	.00
34	-534.56
35	-879.24
36	-1235.23
37	-1560.24
38	-1769.87
39	-1133.70
40	6467.36
41	-42.36
42	-945.66
43	5784.02
44	-192.79
45	-886.79
46	5762.54
47	-178.14
48	-930.72
49	4945.96
50	-248.78
51	-525.33
52	1015.99
53	-703.23
54	2816.07
55	-2433.95
56	9210.41
57	11190.00
58	-4979.40
59	10982.17
60	10878.26

APPENDIX B

MVPM SOURCE CODE

```
      PROGRAM CONSYS (MVPMOD,INPUT=101B/120,OUTPUT=101B/150,
     1                ZZBASE,LPOUT,TAPE5=INPUT,TAPE6=OUTPUT,
     2                TAPE7=LPOUT,TAPE8=MVPMOD,TAPE9=ZZBASE)

C*****************************************************************
C*****************************************************************
C*****
C*****                          MVPM
C*****         A MANUFACTURING VENTURE PLANNING MODEL
C*****
C*****                   CREATED AND WRITTEN BY
C*****                     WALTER JAMES WILSON
C*****
C*****      SCHOOL OF INDUSTRIAL AND SYSTEMS ENGINEERING
C*****            GEORGIA INSTITUTE OF TECHNOLOGY
C*****                ATLANTA, GEORGIA  30332
C*****
C*****                        JULY, 1978
C*****
C*****************************************************************
C*****
C*****                     VARIABLE GLOSSARY
C*****
C*****
C*****
C***** ADMEX (60) (REAL, COMMON=FINUI) =>AGGREGATE
C*****       ADMINISTRATIVE, NONMARKETING, EXPENSE BUDGET.
C***** ADMSAL(60) (REAL, COMMON=FINUI) =>ADMINISTRATIVE
C*****       ,NONMARKETING, SALARY BUDGET.
C***** ADVTEQ (REAL, COMMON=FINUI) =>AD VALOREM TAX RATE ON
C*****       EQUIPMENT.
C***** ADVTIN (REAL, COMMON=FINUI) =>AD VALOREM TAX RATE ON
C*****       INVENTORY.
C***** AVGDN (30) (REAL, COMMON=PCRSC ) =>AVERAGE TOTAL
C*****       PERCENT DOWNTIME (SCHEDULED & UNSCHEDULED).
C***** AVGREJ(20) (REAL, COMMON=PIRSC ) =>AVERAGE PERCENT
C*****       REJECT RATE FOR EACH ITEM.
C***** AVGXRJ(30) (REAL, COMMON=PCRSC ) =>AVERAGE %  EXTRA
C*****       REJECT RATE OVER BASE CASE PC.
C***** AVGXSC(30) (REAL, COMMON=PCRSC ) =>AVERAGE %  EXTRA
C*****       SCRAP RATE OVER BASE CASE PC.
C***** BLDMR (REAL, COMMON=FINUI) =>MONTHLY PLANT BUILDING
C*****       RENTAL PER SQUARE FOOT.
C***** CASHMC (REAL, COMMON=FINUI) =>MINIMUM DESIRED CASH
C*****       CUSHION.
C***** CASHMD (REAL, COMMON=FINUI) =>MINIMUM REQUIRED CASH
C*****       BALANCE AS %  OF OUTSTANDING DEBT.
C***** CBEOP (REAL, COMMON=FINMD) =>CASH BALANCE AT END OF
C*****       PERIOD.
C***** CDEBT (REAL, COMMON=FINMD) =>CUMULATIVE DEBT
```

```
C*****        (BEGINNING OF MONTH).
C***** CONMIN (REAL, COMMON=PRSRSC) =>MINIMUM PERSONNEL
C*****        (SHIFT) REDUCTION PERIOD.
C***** CUMLOS (REAL, COMMON=FINMD) =>CUMULATIVE OPERATING
C*****        LOSS AMOUNT (ANNUAL).
C***** DEPCST(30) (REAL, COMMON=PCRSC ) =>DEPRECIABLE COST
C*****        FOR EACH PROCESS CONFIGURATION.
C***** DREPA (60) (REAL, COMMON=FINMD) =>MONTHLY DEBT
C*****        REPAYMENT (END OF MONTH).
C***** EFFAI (REAL, COMMON=FINUI) =>ANNUAL EFFECTIVE
C*****        INTEREST RATE ON BORROWED FUNDS.
C***** EFFMI (REAL, COMMON=FINMD) =>EFFECTIVE MONTHLY
C*****        INTEREST RATE.
C***** EQSAL (60) (REAL, COMMON=FINMD) =>CASH AMOUNT OF
C*****        EQUIPMENT SALES (SALVAGE, IN TRANSACTION
C*****        MONTH).
C***** EQTYIN (REAL, COMMON=FINUI) =>INITIAL EQITY
C*****        INJECTION.
C***** EUTCON(4,60) (REAL, COMMON=EUTOPN) =>TOTAL ENRGY
C*****        CONSUMPTION (UNITS) BY MONTH.
C***** EUTCST(4) (REAL, COMMON=EUTRSC) =>AVERAGE COST PER
C*****        ENERGY/UTILITY UNIT.
C***** EUTINF(4,4) (REAL, COMMON=EUTRSC) =>ENERGY/UTILITY
C*****        DESCRIPTION (ALPHANUMERIC, 40 CHARACTERS).
C***** EUTNAM(4) (REAL, COMMON=EUTRSC) =>ENERGY/UTILITY
C*****        NAME (10 ALPHANUMERIC).
C***** EUTUNT(4) (REAL, COMMON=EUTRSC) =>ENERGY/UTILITY
C*****        UNITS (10 ALPHANUMERIC).
C***** EUTUSE(30,4) (REAL, COMMON=PCRSC ) =>PROCESS
C*****        CONFIGURATION E/U USAGE PER OPERATING HOUR.
C***** EXLIF (30) (REAL, COMMON=PCRSC ) =>EXPECTED LIFE FOR
C*****        EACH PC (IN YEARS: MUST HAVE NO FRACTIONAL
C*****        PART).
C***** FGDEM (5,60) (REAL, COMMON=FGOPN ) =>PROJECTED
C*****        DEMAND FOR EACH FINISHED GOOD.
C***** FGIBOP (REAL, COMMON=FINMD) =>FINISHED GOODS
C*****        INVENTORY, BOP ($VALUE).
C***** FGINV (5,60) (REAL, COMMON=FGOPN) =>FINISHED GOODS
C*****        INVENTORIES.
C***** FGPRC (5) (REAL, COMMON=FGRSC ) =>FINISHED GOOD
C*****        SELLING PRICE PER UNIT.
C***** FGPRD (5,60) (REAL, COMMON=FGOPN ) =>USER-SPECIFIED
C*****        SCHEDULED FG PRODUCTION (MVPM WILL MODIFY AS
C*****        NEED).
C***** FINRPT(35,10) (REAL, COMMON=FINMD) =>FINANCIAL
C*****        REPORT BUFFER ARRAY.
C***** FIRCST (REAL, COMMON=FINUI) =>COST OF FIRING AS %
C*****        OF MONTHLY RT WAGES.
C***** FLRSPC(30) (REAL, COMMON=PCRSC ) =>TOTAL FLOOR SPACE
C*****        SQUARE FOOTAGE REQ'D FOR EACH PC.
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```
C***** FXOCST(20) (REAL, CCMMON=RMRSC ) =>RAW MATERIAL
C*****        FIXED ORDER COST.
C***** GSALES(5,60) (REAL, COMMON=FGOPN) =>GROSS SALES
C*****        UNITS.
C***** HIRCST (REAL, COMMON=FINUI) =>COST OF HIRING AS %
C*****        OF MONTHLY RT WAGES.
C***** HRSDN (15,60) (REAL, CCMMON=PSOPN ) =>PROCESS STEP
C*****        HRS DOWN IN EACH MONTH.
C***** HRSUTL(15,60) (REAL, CCMMON=PSOPN ) =>PROCESS STEP
C*****        HRS UTILIZED IN EACH MONTH.
C***** IALTPC(15,3) (INTEGER, CCMMON=PSRSC ) =>ALTERNATIVE
C*****        PC'S (3 MAX) FOR EACH PS (ALPHNUM.  CNVRTD.
C*****        TO INDEX).
C***** ICEXS (31,3) (REAL, COMMON=MISC) =>CAPACITY
C*****        EXPANSION SCHEDULE.
C***** IFGPI (5) (INTEGER, COMMON=FGRSC ) =>IDENTIFIER OF
C*****        PI TO WHICH THIS FG CORRESPONDS (A/N CVRTD.
C*****        TO INDX).
C***** INPID (20,10) (INTEGER, COMMON=PIRSC )
C*****        =>ALPHANUMERIC ID OF INPUTS (10 MAX) TO EACH
C*****        PI (CNVRTD.  TO INDEX).
C***** IOUT (INTEGER, COMMCN=MISC) =>OUTPUT DEVICE
C*****        SPECIFICATION VARIABLE.
C***** IPERF (INTEGER, COMMCN=MISC) =>DEVICE NUMBER
C*****        ASSOCIATED WITH PERMANENT MODEL FILE.
C***** IPIPS (20) (INTEGER, CCMMON=PIRSC ) =>ID/INDEX OF PS
C*****        ON WHICH EACH PI IS PRODUCED.
C***** IPSPC (15,60) (INTEGER, COMMON=PSOPN ) =>INDEX OF
C*****        THE PC WHICH EACH PROCESS STEP CONTAINS IN
C*****        EACH MONTH.
C***** IRUNF (INTEGER, COMMCN=MISC) =>DEVICE NUMBER
C*****        ASSOCIATED WITH RUN-TIME MODEL FILE.
C***** ISCOR (15,20) (INTEGER, COMMON=PSRSC ) =>INDICES OF
C*****        PI'S MADE IN EACH PROCESS STEP.
C***** MONTH (1) (INTEGER, COMMCN=MISC ) =>MONTH COUNTER IN
C*****        FULL PLANNING HORIZON OPERATIONS PROJECTION.
C***** NUMEUT (INTEGER, CCMMON=MISC) =>ACTUAL NUMBER OF E/U
C*****        TYPES INPUTTED.
C***** NUMFG (INTEGER, COMMON=MISC) =>ACTUAL NUMBER OF FG'S
C*****        INPUTTED.
C***** NUMPC (INTEGER, COMMCN=MISC) =>ACTUAL NUMBER OF PC'S
C*****        INPUTTED.
C***** NUMPI (INTEGER, COMMON=MISC) =>ACTUAL NUMBER OF PI'S
C*****        INPUTTED.
C***** NUMPS (INTEGER, COMMON=MISC) =>ACTUAL NUMBER OF PS'S
C*****        INPUTTED.
C***** NUMRM (INTEGER, COMMCN=MISC) =>ACTUAL NUMBER OF RM'S
C*****        INPUTTED.
C***** NUMSC (INTEGER, COMMON=MISC) =>ACTUAL NUMBER OF SC'S
C*****        INPUTTED.
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C***** OFCEQ (60) (REAL, CCMMON=FINUI) =>OFFICE EQUIPMENT
C*****        AQUISITION SCHEDULE (BY ACQUISITION MONTH).
C***** OTHRS (15,60) (REAL, CCMMON=PSOPN) =>ACTUAL OT HRS
C*****        FOR EACH PS FOR EACH MONTH.
C***** OTHRS (15,60) (REAL, CCMMON=PSOPN) =>NUMBER CF OT
C*****        HOURS USED IN EACH PS AND MONTH.
C***** OTWAGE(6) (REAL, CCMMON=PRSRSC) =>OVERTIME WAGE
C*****        RATE.
C***** PAYTF (REAL, COMMON=FINUI) =>PAYROLL TAX AND FRINGE
C*****        BENEFIT RATE AS %  OF TOTAL PAYROLL.
C***** PCDFAC(30,6) (REAL, COMMCN=PCRSC ) =>DIFFICULTY
C*****        FACTOR ASOCIATED WITH EACH PC BY SKILL CLASS.
C***** PCINFO(30,4) (REAL, COMMCN=PCRSC ) =>PROCESS STEP
C*****        DESCRIPTIVE INFORMATION (40 ALPHANUMERIC).
C***** PCLST (30) (REAL, CCMMON=PCRSC ) =>TABLE OF PROCESS
C*****        CONFIGURATION IDENTIFIERS (ALPHANUMERIC).
C***** PCOLT (30) (REAL, CCMMON=PCRSC ) =>ORDER LEAD TIME
C*****        IN MONTHS (FOR CAP ACQUISITION $ FLOWS: MUST
C*****        BE INPUT WITH NO FRACTIONAL PART).
C***** PCSTF (30,6) (REAL, COMMCN=PCRSC ) =>REQ'D.
C*****        STAFFING PER SHIFT (BY SC) FOR EACH PROCESS
C*****        CONFIGURATION: MUST BE INPUT WITH NO FRACTIONA
C***** PEQTAX(5) (REAL, COMMON=FINMD) =>PLANT EQUIPMENT TAX
C*****        AMOUNT (END OF YEAR).
C***** PERUNC (REAL, COMMON=FINUI) =>PERCENT
C*****        UNCOLLECTABLES.
C***** PIINFO(20,4) (REAL, COMMCN=PIRSC ) =>PRODUCTION ITEM
C*****        DESCRIPTIVE INFORMATION (40 ALPHANUMERIC).
C***** PILST (20) (REAL, CCMMON=PIRSC ) =>TABLE OF
C*****        PRODUCTION ITEM IDENTIFIERS (ALPHANUMERIC).
C***** PIUNIT(20) (REAL, CCMMON=PIRSC) => UNITS TO BE USED
C*****        FOR EACH PI (ALPHANUMERIC).
C***** PLNTOH (REAL, COMMON=FINUI) =>PLANT OVERHEAD: $ PER
C*****        SCHEDULED PROCESS STEP OPERATING HOUR.
C***** PRINDX(6) (REAL, CCMMON=PRSRSC) =>PRODUCTIVITY INDEX
C*****        FOR EACH SKILL CLASS.
C***** PRVHOT(15) (REAL, CCMMCN=PSOPN) =>THE NUMBER OF
C*****        PERIODS FOR WHICH ABOVE "LONG RUN" OT HAS BEEN
C*****        USED.
C***** PSLST (15) (REAL, CCMMON=PSRSC ) =>TABLE OF PROCESS
C*****        STEP IDENTIFIERS (ALPHANUMERIC).
C***** RMAVL (20,60) (REAL, CCMMON=RMOPN ) =>UNITS CF EACH
C*****        RAW MATERIAL AVAILABLE IN EACH MONTH.
C***** RMIBOP (REAL, COMMON=FINMD) =>RAW MATERIALS
C*****        INVENTORY, BOP ($VALUE).
C***** RMINFO(4,20) (REAL, COMMON=RMRSC ) =>RAW MATERIAL
C*****        DESCRIPTIVE INFORMATION (40 ALPHANUMERIC).
C***** RMINV (20,60) (REAL, CCMMON=RMOPN) =>RAW MATERIALS
C*****        INVENTORIES.
C***** RMLST (20) (REAL, COMMON=RMRSC ) =>TABLE OF RAW
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C*****        MATERIAL IDENTIFIERS (ALPHANUMERIC).
C***** RMOLT  (20) (REAL, COMMON=RMRSC ) =>RAW MATERIAL
C*****        ORDER LEAD TIME (MONTHS: MUST BE INPUT WITH NO
C*****        FRACTIONAL PART).
C***** RMORD  (20,61) (REAL, COMMON=RMOPN ) =>UNITS OF RM'S
C*****        ON ORDER IN EACH MONTH: 1ST COL.  IS FOR
C*****        "STARTUP".
C***** RMUNIT(20) (REAL, COMMON=RMRSC) => UNITS TO BE USED
C*****        FOR EACH RM (ALPHANUMERIC).
C***** RMUSED(20,60) (REAL, COMMON=RMOPN) =>RM'S ACTUALLY
C*****        REQUIRED FOR PRODUCTION IN EACH MONTH.
C***** RMVCST(20) (REAL, COMMON=RMRSC ) =>RAW MATERIAL
C*****        VARIABLE COST PER UNIT.
C***** RTWAGE(6) (REAL, COMMON=PRSRSC) =>REGULAR TIME WAGE
C*****        RATE.
C***** SCHPD  (20,60) (REAL, COMMON=PIOPN ) =>INTERNALLY
C*****        GENERATED PRODUCTION SCHEDULE (UNITS) FOR EACH
C*****        PI.
C***** SCLST  (6) (REAL, COMMON=PRSRSC) =>TABLE OF SKILL
C*****        CLASS IDENTIFIERS (ALPHANUMERIC).
C***** SETLT  (30) (REAL, COMMON=PCRSC ) =>PROCESS
C*****        CONFIGURATION SETUP LEAD TIME(MONTHS: MUST BE
C*****        INPUT WITH NO FRACTIONAL PARTS).
C***** SHFCNT(15,60) (REAL, COMMON=PSOPN) =>NUMBER OF
C*****        SHIFTS USED IN EACH PS AND MONTH.
C***** SMKTEX(60) (REAL, COMMON=FINUI) =>SALES AND
C*****        MARKETING EXPENSE BUDGET.
C***** SPACE  (300) (REAL, COMMON=SCRTCH) =>WORKSPACE FOR
C*****        DYNAMIC ALLOCATION OF WORKING ARRAY STORAGE IN
C*****        MAIN & SUBROUTINES AS NEEDED.
C***** SULOAN (REAL, COMMON=FINUI) =>STARTUP LOAN AMOUNT.
C***** SURCAP(15,60) (REAL, COMMON=PSOPN) =>AVAILABLE
C*****        SURPLUS CAPACITY IN EACH PS AND MONTH.
C***** SVGVAL(30) (REAL, COMMON=PCRSC ) =>PROCESS
C*****        CONFIGURATION SALVAGE VALUE AT END OF LIFE.
C***** TODPR  (20) (REAL, COMMON=FINMO) =>TOTAL QUARTERLY
C*****        OFFICE EQUIPMENT DEPRECIATION AMOUNT.
C***** TOTINV(30) (REAL, COMMON=PCRSC ) =>TOTAL INVESTMENT
C*****        REQ'D TO MAKE EACH PROCESS STEP OPERATIONAL.
C***** TPDPR  (20) (REAL, COMMON=FINMO) =>TOTAL QUARTERLY
C*****        PLANT EQUIPMENT DEPRECIATION AMOUNT.
C***** UNREJ  (20,60) (REAL, COMMON=PIOPN ) =>UNITS REJECTED
C*****        OF EACH PI IN EACH MONTH.
C***** XHIOT  (REAL, COMMON=PRSRSC) =>MAXIMUM PERMISSABLE
C*****        LEVEL OF OT.
C***** XINBRK (REAL, COMMON=FINUI) =>TAXABLE INCOME
C*****        BREAKPOINT OVER WHICH SURTAX MUST BE PAID.
C***** XINCTX(20) (REAL, COMMON=FINMO) =>TOTAL INCOME TAX
C*****        PAYMENT PER QUARTER.
C***** XINQTY (20,10) (REAL, COMMON=PIRSC ) =>NUMBER OF
```

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C*****        UNITS OF EACH INPUT REQUIRED PER UNIT OUTPUT.
C***** XINSCP(20,10) (REAL, CCMMON=PIRSC ) =>AVERAGE %
C*****        SCRAP RATE FOR EACH INPUT TO EACH PI.
C***** XINSUR (REAL, COMMON=FINUI) =>CORPORATE INCOME
C*****        SURTAX RATE.
C***** XINTAX (REAL, COMMON=FINUI) =>CORPORATE INCOME TAX
C*****        RATE.
C***** XINTEX(60) (REAL, COMMON=FINMD) =>INTEREST EXPENSE
C*****        (END OF MONTH).
C***** XIVTAX(5) (REAL, CCMMON=FINMD) =>INVENTORY TAX
C*****        AMOUNT (END OF YEAR).
C***** XLOAN (60) (REAL, CCMMON=FINMD) =>MONTHLY BORROWING
C*****        (BEGINNING OF MONTH).
C***** XLROT (REAL, COMMON=PRSRSC) =>LONG RUN LEVEL OF OT.
C***** XMAXOR(30) (REAL, CCMMON=PCRSC ) =>MAXIMUM
C*****        ATTAINABLE OUTPUT RATE FOR EACH PROCESS
C*****        CONFIGURATION.
C***** XMAXSH (REAL, COMMON=PRSRSC) =>MAXIMUM ALLOWABLE
C*****        NUMBER OF SHIFTS (.LE.  3).
C***** XMCHDF(20) (REAL, CCMMON=PIRSC ) =>MECHANICAL
C*****        DIFICULTY FACTOR INHERENT IN PRODUCTION OF
C*****        EACH PI.
C***** XMEQV (REAL, COMMON=FINUI) =>MIN.  EQUIP.  VALUE- AS
C*****        %  OF CRIGINAL DEPRECIABLE COST (FOR AD VAL.
C*****        TAX COMPUTATICNS).
C***** XMINOQ(20) (REAL, CCMMON=RMRSC ) =>RAW MATERIAL
C*****        MINIMUM ORDER QUANTITY (UNITS).
C***** XMXHOT (REAL, COMMON=PRSRSC) => MAXIMUM ALLOWABLE
C*****        NUMBER CF HIGH OT MONTHS.
C***** XNCF (60) (REAL, CCMMON=FINMC) =>NET CASH FLOW (END
C*****        OF MONTH).
C***** XNINC (20) (REAL, CCMMON=FINMD) =>NET INCOME PER
C*****        QUARTER.
C***** XNUMSM(15) (REAL, CCMMCN=PSOPN) =>NUMBER OF MONTHS
C*****        THAT PRESENT OR SMALLER SHIFT SIZE HAS BEEN
C*****        USED.
C*****
C*****                       NAMED COMMON AREAS
C*****
C***** EUTOPN ENERGY/UTILITY OPERATIONS DATA.
C***** EUTRSC ENERGY/UTILITY RESOURCE DATA.
C***** FGOPN FINISHED GOODS OPERATICNS DATA.
C***** FGRSC FINISHED GOODS RESOURCE DATA.
C***** FINMD GENERAL FINANCIAL VARIABLE AREA- MODEL
C*****        GENERATED INFORMATION.
C***** FINUI GENERAL FINANCIAL VARIABLE AREA- USER INPUT
C*****        INFORMATION.
C***** MISC MISCELANEOUS VARIABLE STORAGE (GLOBAL COUNTER
C*****        VARIABLES, I/O DEVICE NUMBERS, CAPITAL
C*****        EXPANSICN SCHEDULE).
```

```
C***** PCRSC PROCESS CONFIGURATION RESOURCE DATA.
C***** PIOPN PRODUCTION ITEM OPERATIONS DATA.
C***** PIRSC PRODUCTION ITEM RESOURCE DATA.
C***** PRSRSC PERSONNEL RESOURCE DATA.
C***** PSOPN PROCESS STEP OPERATIONS DATA.
C***** PSRSC PROCESS STEP RESOURCE DATA.
C***** RMOPN RAW MATERIALS OPERATIONS DATA.
C***** RMRSC RAW MATERIALS RESOURCE DATA.
C***** SCRTCH GENERAL WORKSPACE (NOT DEDICATED TO ANY
C*****       SPECIFIC DATA ITEM- AVAILABLE FOR TEMPORARY
C*****       VARIABLE STORAGE ALLCCATION AS NEEDED
C*****
C*****                          PROGRAM UNITS
C*****
C***** ASNPI (SUBROUTINE) INPUT PI PRODUCTION ASSIGNMENT.
C***** ASNRM (SUBROUTINE) RM PURCHASE ASSIGNMENT.
C***** BLOCK DATA (SUBROUTINE) DATA INITIALIZATION.
C***** CAPEXP (SUBROUTINE) CAPITAL EXPANSION ROUTINE.
C***** CFL6M (SUBROUTINE) CASH FLOW GENERATION- 6 MONTHS &
C*****       STARTUP.
C***** CFSTMT (SUBROUTINE) CASH FLOW REPORT GENERATION.
C***** CONSYS **MAIN PROGRAM** MODEL CONTROL SYSTEM.
C***** DATMOD (SUBROUTINE) DATA DISPLAY AND MODIFICATION
C*****       CONTROL (USER INTERFACE).
C***** DEPAVT (SUBROUTINE) EQUIPMENT DEPRECIATION AND AD
C*****       VALOREM TAXES.
C***** EMPLEV (SUBROUTINE) STAFFING DETAILS FOR GIVEN PS IN
C*****       GIVEN MONTH.
C***** EUTIN (SUBROUTINE) ENERGY/UTILITY DATA ENTRY AND
C*****       TESTING.
C***** EUTOUT (SUBROUTINE) ENERGY/UTILITY DATA DISPLAY.
C***** FDISP (SUBROUTINE) FINANCIAL OPERATICNS DATA
C*****       DISPLAY.
C***** FGIN (SUBROUTINE) FINISHED GOODS DATA ENTRY AND
C*****       TESTING.
C***** FGOUT (SUBROUTINE) FINISHED GOODS DATA DISPLAY.
C***** FGPROD (SUBROUTINE) FINISHED GOODS PRODUCTION
C*****       SCHEDULES.
C***** FINANL (SUBROUTINE) FINANCIAL ANALYSIS- DISCOUNTED
C*****       CASH FLOW AND KEY RATIOS.
C***** FINSUB (SUBROUTINE) FINANCIAL REPORT INFORMATION
C*****       CONTROL.
C***** GFIN (SUBROUTINE) GENERAL FINANCIAL DATA ENTRY AND
C*****       TESTING.
C***** GFOUT (SUBROUTINE) GENERAL FINANCIAL DATA DISPLAY.
C***** INC4Q (SUBROUTINE) ACCOUNTING INCOME GENERATION- 4
C*****       QUARTERS & ANNUAL.
C***** INFIND (SUBROUTINE) USER ENTERED PROCESS INPUT ID
C*****       VALIDITY CHECK.
C***** INIT (SUBROUTINE) INITIAL DATA ENTRY (USER
```

```
C*****        INTERFACE).
C***** INSTMT (SUBROUTINE) INCOME STATEMENT GENERATION.
C***** INTEST (FUNCTION) REAL NUMBER INPUT TESTING- UPPER &
C*****        LOWER BOUNDS, WHOLE NUMBER RESTRICTIONS.
C***** INVEN (SUBROUTINE) INVENTORY STATISTICS, GROSS SALES
C*****        UNITS.
C***** MDUMP (SUBROUTINE) BINARY DATA DUMP (TO PERMANENT OR
C*****        RUN-TIME MODEL FILES).
C***** MLOAD (SUBROUTINE) BINARY DATA LOAD (FROM PERMANENT
C*****        OR RUN-TIME MODEL FILES).
C***** MPLOT (SUBROUTINE) SELECTED DATA PLOTS (LINE PRINTER
C*****        OR TERMINAL).
C***** NFDISP (SUBROUTINE) NONFINANCIAL OPERATIONS DATA
C*****        DISPLAY.
C***** NUMIN (SUBROUTINE) ITEM COUNTER ENTRY AND ERROR
C*****        CHECK.
C***** PCFIND (SUBROUTINE) PS TO PC CORRESPONDENCE SEARCH.
C***** PCIN (SUBROUTINE) PROCESS CONFIGURATION DATA ENTRY
C*****        AND TESTING.
C***** PCOUT (SUBROUTINE) PROCESS CONFIGURATION DATA
C*****        DISPLAY.
C***** PIIN (SUBROUTINE) PRODUCTION ITEM DATA ENTRY AND
C*****        TESTING.
C***** PIOUT (SUBROUTINE) PRODUCTION ITEM DATA DISPLAY.
C***** PIPROD (SUBROUTINE) PRODUCTION ITEM PRODUCTION
C*****        SCHEDULES, RM PURCHASING, OTHER INPUT SCHED'S.
C***** PRDCON (SUBROUTINE) MANUF.  PRODUCTION CONFIGURATION
C*****        (MACH.  & LABOR HOURS, ETC.)
C***** PRSIN (SUBROUTINE) PERSONNEL DATA ENTRY AND TESTING.
C***** PRSOUT (SUBROUTINE) PERSONNEL DATA DISPLAY.
C***** PSIN (SUBROUTINE) PROCESS STEP DATA ENTRY AND
C*****        TESTING.
C***** PSOUT (SUBROUTINE) PROCESS STEP DATA DISPLAY.
C***** RMIN (SUBROUTINE) RAW MATERIALS DATA ENTRY AND
C*****        TESTING.
C***** RMOUT (SUBROUTINE) RAW MATERIALS DATA DISPLAY.
C***** RMPUR (SUBROUTINE) RAW MATERIALS PURCHASING SCHED.
C*****        CORRECTIONS (MIN.  ORD.  QTY., ETC.).
C***** USCHED (SUBROUTINE) USER DIRECTED SHCEDULE
C*****        GENERATION (DEM.  SCHEDULES, EXPENSE BUDGETS,
C*****        ETC.)
C***** ZERO (SUBROUTINE) OPERATIONS DATA ARRAY
C*****        REINITIALIZATION.
C*****
C*****                      FILE UTILIZATION
C*****
C***** INPUT (DEVICE# 5) INTERACTIVE TERMINAL INPUT.
C***** LPOUT (DEVICE# 7) TEMPORARY STORAGE FOR OUTPUT
C*****        INFORMATION PRIOR TO BEING SENT TO HIGH SPEED
C*****        PRINTER.
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C***** MVPMOD (DEVICE# 8) PERMANENT MODEL FILE.
C***** OUTPUT (DEVICE# 6) INTERACTIVE TERMINAL OUTPUT.
C***** ZZBASE (DEVICE# 9) RUN-TIME BASE MODEL.
C*****
C**************************************************************


      COMMON/PSRSC/PSLST(15),IALTPC(15,3),ISCOR(15,20)
      COMMON/PSOPN/IPSPC(15,60),HRSDN(15,60),HRSUTL(15,60),
     1             PRVHOT(15),XNUMSM(15),SHFCNT(15,60),
     2             OTHRS(15,60),SURCAP(15,60)
      COMMON/PCRSC/PCLST(30),PCINFO(30,4),PCOLT(30),
     1             SETLT(30),EXLIF(30),XMAXCR(30),AVGDN(30),
     2             AVGXRJ(30),AVGXSC(30),TOTINV(30),
     3             DEPCST(30),SVGVAL(30),EUTUSE(30,4),
     4             FLRSPC(30),PCSTF(30,6),PCDFAC(30,6)
      COMMON/PIRSC/PILST(20),PIINFO(20,4),IPIPS(20),
     1             XMCHDF(20),AVGREJ(20),INPID(20,10),
     2             XINQTY(20,10),XINSCP(20,10),PIUNIT(20)
      COMMON/PIOPN/SCHPD(20,60),UNREJ(20,60)
      COMMON/FGRSC/IFGPI(5),FGPRC(5)
      COMMON/FGOPN/FGDEM(5,60),FGPRD(5,60),
     1             FGINV(5,60),GSALES(5,60)
      COMMON/RMRSC/RMLST(20),RMINFO(20,4),
     1             FXOCST(20),RMOLT(20),XMINOQ(20),
     2             RMVCST(20),RMUNIT(20)
      COMMON/RMOPN/RMAVL(20,60),RMORD(20,61),RMUSED(20,60),
     1             RMINV(20,60)
      COMMON/PRSRSC/SCLST(6),RTWAGE(6),OTWAGE(6),PRINDX(6),
     1              XMXHOT,XLROT,XHIOT,XMAXSH,CCNMIN
      COMMON/EUTRSC/EUTNAM(4),EUTINF(4,4),EUTUNT(4),
     *  EUTCST(4)
      COMMON/EUTOPN/EUTCON(4,60)
      COMMON/MISC/MCNTH,NUMFG,NUMPS,NUMPC,NUMPI,NUMRM,NUMSC,
     1           NUMEUT,ICEXS(31,3),IRUNF,IPERMF,IOUT
      COMMON/SCRTCH/SPACE(300)
      COMMON/FINUI/PERUNC,SMKTEX(60),BLDMR,PLNTOH,
     1             ADMSAL(60),OFCEQ(60),ADMEX(60),EQTYIN,
     2             EFFAI,PAYTF,XINTAX,XINSUR,XINBRK,
     3             HIRCST,FIRCST,CASHMC,CASHMD,SULOAN,
     4             ADVTEQ,ADVTIN,XMEQV
      COMMON/FINMD/FINRPT(35,10),XNCF(60),TODPR(20),
     1             TPDPR(20),CUMLOS,XINCTX(20),XNINC(20),
     2             XINTEX(60),CBEOP,FGIBOP,RMIBOP,CDEBT,
     3             XLOAN(60),EFFMI,DREPA(60),PEQTAX(5),
     4             XIVTAX(5),EQSAL(60)

C**************************************************************
C***** DEVICE NUMBERS ARE ASSIGNED FOR THE PERMANENT
C***** AND RUNTIME BASE MODEL FILES.
```

```
C*****************************************************************
      IPERMF=8
      IRUNF=9

C***** REPORT OUTPUT FILE IS INITIALIZED TO DEV# 6
C***** WHICH IS THE TERMINAL (FILE "OUTPUT").
      IOUT=6

C*****************************************************************
      CALL DATE(XDATE)
      WRITE(6,1000) XDATE
 1000 FORMAT(10(/),80(1H*)/10X,10(1H=),"> MANUFACTURING ",
     1    "VENTURE PLANNING MODEL <",10(1H=)//
     2    20X,"RUN DATE: ",A10/80(1H*),5(/))
C*****************************************************************

C*****************************************************************
C***** SUBROUTINE INIT PERFORMS INITIAL DATA READS AND
C***** MANIPULATION. FILES ARE REWOUND BEFORE READING.
C***** ID'S (ALPHANUMERIC) ARE CHANGED TO INDICES
C***** (INTEGER) WHERE NECESSARY.
C*****************************************************************
C***** USER HAS OPTION OF BUILDING MODEL
C***** WITHOUT RUNNING IT.
C*****************************************************************
      CALL INIT
      WRITE(6,1050)
 1050 FORMAT(5(/),"DO YOU WISH TO RUN SIMULATION?",
     1    " (YES OR NO)")
      READ(5,2010)URESP
      IF(URESP.NE.3HYES) GOTO 150

C*****************************************************************
C***** COMPUTE PI/PS CORESPONDENCE: COMPILE LIST OF
C***** ITEMS PRODUCED ON EACH PROCESS STEP.
C*****************************************************************

   10 DO 100 IPI=1,NUMPI
C***** IPS2 BECOMES INDEX OF THE PS ON WHICH THIS
C***** PI IS MADE.
           IPS2=IPIPS(IPI)
C***** FOR THE ROW IN ISCOR ASSOCIATED WITH THIS PS,
C***** FIND AN OPEN ELEMENT.  SET THIS ELEMENT EQUAL
C***** TO IPI - THE INDEX OF THIS PI.
           DO 110 ICNT=1,20
              IF(ISCOR(IPS2,ICNT).NE.0) GOTO 110
              ISCOR(IPS2,ICNT)=IPI
              GOTO 100
  110         CONTINUE
  100      CONTINUE
```

```
C******************************************************************
C***** FOR MONTHS ONE THROUGH 60, SET UP PRODUCTION
C***** SCHEDULES FOR ALL PI'S AND DETERMINE CONFIGURATION
C***** MANUFACTURING OPERATIONS  (EQUIPMENT, MANPOWER, ETC.)
C***** >>>FGPROD= FINISHED GOODS PROD. SCHEDULE GENERATOR.
C***** >>>PIPROD= INTERMEDIATE PI PROD. SCHEDULE GENERATOR.
C***** >>>PROCON= MANUFACTURING CONFIGURATION GENERATOR.
C******************************************************************

      DO 130 MONCNT=1,60
C***** MONTH IS NOT USED AS INDEX OF LOOP DUE TO
C***** PROBLEMS CAUSED IN CODE OPTIMIZATION WHEN
C***** COMMON VARIABLES ARE USED IN SUCH A FASHION.
           MONTH=MONCNT
C***** ASSIGN FINISHED GOODS PRODUCTION.
  125      CALL FGPROD
C***** ASSIGN INTERMEDIATE PRODUCTION.
           CALL PIPROD(1)
           IRESCH=0
C***** THE RESCHEDULING FLAG HAS BEEN SET TO ZERO.
C***** IF PROCON RETURNS IT WITH A VALUE OF ONE, THEN
C***** RESCHEDULING WILL BE NECESSARY FOR CURRENT MONTH.
C***** IF IT HAS BEEN ASSIGNED A VALUE OF 2,
C***** THEN THE USER MUST END THE RUN OR MODIFY
C***** PRODUCTION AND/OR PC DATA AND RERUN.
           CALL PROCON(IRESCH)
           IF(IRESCH.EQ.1) GOTO 125
           IF(IRESCH.EQ.2) GOTO 150
C***** NO RESCHEDULING IS NECESARY THIS MONTH. RAW
C***** MATERIALS ORDERING (IN PREVIOUS MONTHS) NEEDED
C***** TO SUPPORT PRODUCTION IN THE PRESENT MONTH ARE
C***** ORDERED.
           CALL PIPROD(2)
  130      CONTINUE

C******************************************************************
C***** RMPUR  MAKES ADJUSTMENTS TO THE RAW MATERIALS
C***** PURCHASING SCHEDULE TO ACCOUNT FOR MIN. ORDER
C***** QUANTITY RESTRICTIONS.
C***** IF AN INFEASIBILITY HAS ARISEN DUE TO USER
C***** SPECIFIED MINIMUM ORDER QUANTITY RESTRICTIONS,
C***** THEN THE ENTIRE SIMULATION MUST BE RERUN AFTER
C***** SUITABLE DATA MODIFICATIONS.
C******************************************************************
      IRERUN=0
      CALL RMPUR(IRERUN)
      IF(IRERUN.EQ.1) GOTO 150

C******************************************************************
```

```
C***** INVEN PERFORMS INVENTORY CALCULATIONS FOR RAW
C***** MATERIALS AND FINISHED GOODS, AS WELL AS GROSS
C***** SALES UNITS DETERMINATION.
C*****************************************************************
      CALL INVEN

      WRITE(6,1070)
 1070 FORMAT(///,5X,30(1H*)/5X,"*****SIMULATION",
     1    " COMPLETED*****"/5X,30(1H*))

C*****************************************************************
C***** NFDISP GENERATES & CONTROLS NONFIN. DATA DISPLAY.
C*****************************************************************
      CALL NFDISP

C*****************************************************************
C********** FINANCIAL SUBROUTINES
C***** >>>FINSUB= FINANCIAL REPORTING SUBROUTINE
C*****************************************************************
      CALL FINSUB

C*****************************************************************
C***** >>>FDISP= FINANCIAL INFORMATION DISPLAY ROUTINE.
C*****************************************************************
      CALL FDISP

C*****************************************************************
C***** >>>FINANL= FINANCIAL ANALYSIS ROUTINE.
C*****************************************************************
      CALL FINANL

C*****************************************************************
C*****>>>MPLOT= PLOT GENERATION ROUTINE.
C*****************************************************************
      CALL MPLOT

  150 WRITE(6,2000)
 2000 FORMAT(//"DO YOU WISH CURRENT MODEL TO BE STORED ",
     1       "AS THE TEMPORARY (RUN-TIME) BASE MODEL?",
     2       " (YES OR NO)")
      READ(5,2010)URESP
 2010 FORMAT(A3)
      IF (URESP.EQ.3HYES) CALL MDUMP(IRUNF)
      WRITE(6,2020)
 2020 FORMAT(/"DO YOU WISH TO MODIFY AND/OR DISPLAY DATA?",
     1    "(YES OR NO)")
      READ(5,2010)URESP
      IF(URESP.NE.3HYES) GOTO 20
C***** USER MAY MODIFY SELECTED DATA ITEMS.
      CALL DATMOD
```

```
   20 WRITE(6,2022)
 2022 FORMAT(/"DO YOU WISH TO RERUN SIMULATION?",
     1     " (YES OR NO)")
      READ(5,2010) URESP
      IF(URESP.NE.3HYES) GOTO 22
C***** OPERATIONS DATA ARRAYS FROM THE LAST RUN ARE ZEROED.
C***** BRANCH TO 10 FOR FULL SIMULATION.
      CALL ZERO
      GOTO 10

C******************************************************************
C***** END OF MAIN PORTION OF CONTROL SYSTEM.
C***** BELOW ARE A FEW PRE-STOP ACTIVITIES.
C******************************************************************

   22 WRITE(6,2028)
 2028 FORMAT(//"DO YOU WISH TO STORE DATA WITH PRESENT",
     1     " MODIFICATIONS AS PERMANENT BASE MODEL? ",
     2     "(YES OR NO)")
      READ(5,2010)URESP
      IF(URESP.NE.3HYES) GOTO 25
      CALL MDUMP(IPERMF)
      GOTO 999

   25 WRITE(6,2030)
 2030 FORMAT(/"DO YOU WISH TO STORE CURRENT TEMPORARY BASE",
     1     " MODEL AS THE PERMANENT BASE MODEL?",
     2     " (YES OR NO)")
      READ(5,2010)URESP
      IF(URESP.NE.3HYES) GOTO 999
      CALL MLOAD(IRUNF)
      CALL MDUMP(IPERMF)

  999 STOP
      END
```

BIBLIOGRAPHY

1. Baker, Kenneth R., Damon W. W., "A Simultaneous Planning Model for Production and Working Capital," Decision Sciences, V. 8, (1977).

2. Brigham, E. F. and K. V. Smith, "The Cost of Capital to the Small Firm," The Engineering Economist, V. 13 (Fall, 1967).

3. Brown, J., "Designing an Accounting System for a Small Business," Management Accounting, V. 56, N. 12 (June, 1975).

4. Burrill, C. W., "A Computer Model of a Growth Company," in Schrieber [53].

5. Carleton, W. T., Charles L. Dick, Jr., David H. Downes, "Financial Policy Models: Theory and Practice," J. of Fin. and Quant. Analysis (December, 1973).

6. Chambers, J. C., S. K. Mullick, and D. D. Smith, "The Use of Simulation Models at Corning Glass Works," in Schrieber [53].

7. Chapman, C. H., "A Small Business Financial Model," Management Accounting, (July, 1975).

8. Chen, H-C., and Kick, R. C., Jr., "A Computer Based Financial Management System for Small Business," Management Adviser, V. 10, N. 6, (November, 1973).

9. Chen, K-C., "A Conceptual Structure of Corporate Strategic Planning Information Systems," Managerial Planning, (September/October, 1977).

10. Clifton, D. S., Jr. and D. E. Fyffe, Project Feasibility Analysis: A Guide to Profitable New Ventures. New York: John Wiley and Sons, 1977.

11. Danniels, E. J., "A Long Range Planning Model for a New Firm in a Growth Market," J. of Industrial Engineering, V. 15, N. 1.

12. Davis, K. R., Marketing Management, Third Edition, New York: The Ronald Press, 1972.

13. DesJardins, R. B., and W. B. Lee, "A Corporate Simulation Model of a Small Manufacturing Firm," in Schrieber [53].

14. Dickson, G. W., J. J. Mauriel, and J. C. Anderson, "Computer Assisted Planning Models: A Functional Analysis," in Schrieber [53].

15. Dickens, J. H., "Linear Programming in Corporate Simulation," in Schrieber [53].

16. Dzlelinski, B. P., "A Guide to Financial Planning Tools and Techniques," IBM Systems Journal, V. 12, N.2.

17. Elnicki, R. A., "ROI Simulation for Investment Decisions," Management Accounting, (February, 1970).

18. Financial Analysis and Planning System, Product Description, On-Line Decisions, Inc., Berkeley, California, 1969.

19. Forrester, A. M., "Simplified Financial Modeling Via Time Sharing," The J. of Accountancy, V. 139, N. 3 (March, 1975).

20. Frendeway, J. O., Jr., R. W. Duea, Jr., D. E. Monarchi, and R. H. Taylor, "General Guidelines Regarding the Transferability of Computer-Based Socio-Economic, Land-Use, and Environmental Models," Business Research Division, Graduate School of Business Administration, University of Colorado, Boulder, Colorado. National Technical Information Service (NTIS) Report Number NSF/RA-770377.

21. Fuehrer, Walter, "Corporate Modeling: A Selective Focus Will Make it Work," Managerial Planning, V. 25, N. 3, (November/December, 1976).

22. Gershefski, G. W., "Corporate Models - The State of the Art," in Schrieber [53].

23. Gershefski, G. W., "Building a Corporate Financial Model," Harvard Business Review, (July/August, 1969).

24. Gilmore, Frank F., "Strategic Planning's Threat to Small Business," California Management Review, V. 9, N. 2, (Winter, 1966).

25. Golde, R. A., "Practical Planning for Small Business," Harvard Business Review, V. 42, N. 5, (September,October, 1964).

26. Grinyer, P. H. and Christopher D. Batt, "Some Tentative Findings on Corporate Financial Simulation Models," Operational Research Quarterly, V. 25, N. 1.

27. Hammond, III, J. S., "Do's and Don't's of Computer Models for Planning," Harvard Business Review, V. 52, N. 2, (March/April, 1974).

28. Hamilton, W. F. and A. Moses, "An Optimization Model for Corporate Financial Planning," Journal of the Operations Research Society, V. 23 (May/June, 1973).

29. Harrison, F. G. and A. Baker, "The Accountant Takes to Models," Operations Research Quarterly, V. 25, N. 1.

30. Hayes, R. H. and R. L. Nolan, "What Kind of Corporate Modeling Functions Best?," Harvard Business Review, V. 52, N. 3, (May/June, 1974).

31. Jackson, J. R., "A Computing Procedure for a Line Balancing Problem," Management Science, V. 2., N. 3, (April, 1956).

32. Kick R. C., Jr., "A Profit Planning and Control System (PPCS) for the Small Firm," Journal of Small Business Management, V. 14, N. 4, (October, 1976).

33. Kingston, P. L., "Concepts of Financial Models," IBM Systems Journal, V. 12, N. 2.

34. Komar, R., "Developing a Liquidity Management Model," Journal of Bank Research, (Spring, 1971).

35. Krouse, Clement, G., "A Model for Aggregate Financial Planning," Management Science, V. 18, N. 10, (June, 1972).

36. Linneman, R. E. and John D. Kennell, "Shirt-Sleeve Approach to Long-Range Plans," Harvard Business Review, (March/April, 1977).

37. Little, John D. C., "Models and Managers: The Concept of a Decision Calculus," Management Science, V. 16, N. 8, (April, 1970).

38. Lorange, P. and J. F. Rockart, "A Framework for the Use of Computer Based Models in the Planning Process," in Lorange and Vancil [39].

39. Lorange, P. and R. F. Vancil, Strategic Planning Systems, Englewood Cliffs, N. J., Prentice-Hall, 1977.

40. Lorange, P. and Richard F. Vancil, "How to Design a Strategic Planning System," Harvard Business Review, (September/October, 1976).

41. Madnick, S. E., "Trends in Computers and Computing: The Information Utility," Science, V. 195, (March, 1977).

42. Mathes, R. C., "'D' People and 'S' People," (Letter), Science, V. 164, (May 9, 1969).

43. McGrail, George R., "Information Systems for Small Businesses," (March/April, 1974).

44. McRae, Thomas W., "Financial Computer Models," Management Decision, (U.K.), V. 15, N. 1 (1977).

45. Mills, H. D., "Software Engineering." Science, V. 195, (March, 1977).

46. Naylor, T. H. and H. Shauland, "A Survey of Users of Planning Models," Management Science, V. 22, (May, 1976).

47. O'Connor, R., Corporate Guides to Long-Range Planning, New York: The Conference Board, Inc., 1976.

48. Planning Systems Generator II, General Information Manual, Form No. GH20-1035-1, IBM Corporation, Data Processing Division, White Plains, N.Y., 1971.

49. Prophit II Reference Manual, The Service Bureau Corporation, New York, 1977.

50. Rhoads, J. L., "Tax Considerations for a Small Business," Management Accounting, (January, 1975).

51. Russo, J. A., Jr., "What to Look for in Computer Assisted Planning Systems," Managerial Planning, V. 25, N. 1, (July/August, 1976).

52. Said, K. E. and J. K. Hughey, "Managerial Problems of the Small Firm," Journal of Small Business Management, V. 15, N. 1.

53. Schrieber, Albert N., Ed., Corporate Simulation Models, Seattle, College of Business Administration of the University of Washington, and the College of Gaming and Simulation of the Institute of Management Science, 1970.

54. Scott, David F., Jr., "Financial Structure Planning for the Small Firm," Journal of Small Business Mgt., V. 13, N. 1., (January, 1975).

55. Shank, John H., Edward G. Niblock, and William T. Sandalls, Jr., "Balance 'Creativity' and 'Realism' in Formal Planning," in Lorange and Vancil [39].

56. Shuman, J. C., "Corporate Planning in Small Companies - A Survey," Long Range Planning, (October, 1975).

57. Smith, L. D., "A Short Term Planning Model for Manufacturing Firms," Unpublished Disertation, University of Minnesota, 1972.

58. Spradlin, B. C. and C. Konstans, "Controlling Cash Constrained Enterprises," Managerial Planning, V. 25, N. 1, (July/August, 1976).

59. Still, T. W., "An Exploratory Investigation of Strategic Planning Behavior in Small Businesses," Unpublished Dissertation, Florida State University, 1974.

60. Stone, B. K., "Cash Planning and Credit-Line Determination With a Financial Statement Simulator: A Case Report on Short-Term Finan-

cial Planning," Journal of Financial and Quantitative Analysis, (December, 1973).

61. Stone, B. K., D. H. Downes, and R. P. MaGee, "Computer-Assisted Financial Planning: The Planner-Model Interface," Journal of Business Research, (June, 1977).

62. Tisone, Albert A., "The Development of a General Model for Personnel and Financial Planning," Unpublished Dissertation, George Washington University, 1966.

63. Welsh, J. A. and J. F. White, "Cashflow Forecasting: One Solution to Inadequate Financing," Journal of Small Business Management, V. 13, N. 1, (January, 1975).

64. Wheelwright, S. C., "Strategic Planning in the Small Business," Business Horizons, V. 14, N. 4, (August, 1971).

65. Zimmer, R. K., and J. C. Gray, "Budget Control Assimilation in Small and Medium Sized Firms," Managerial Planning, (November/December, 1973).